Vegetation of the Outer Banks of North Carolina

by

Clair A. Brown

LOUISIANA STATE UNIVERSITY PRESS
Baton Rouge

LOUISIANA STATE UNIVERSITY STUDIES

Coastal Studies Series

JAMES P. MORGAN, Editor

Number Four

VEGETATION OF THE OUTER BANKS OF NORTH CAROLINA

LOUISIANA STATE UNIVERSITY STUDIES

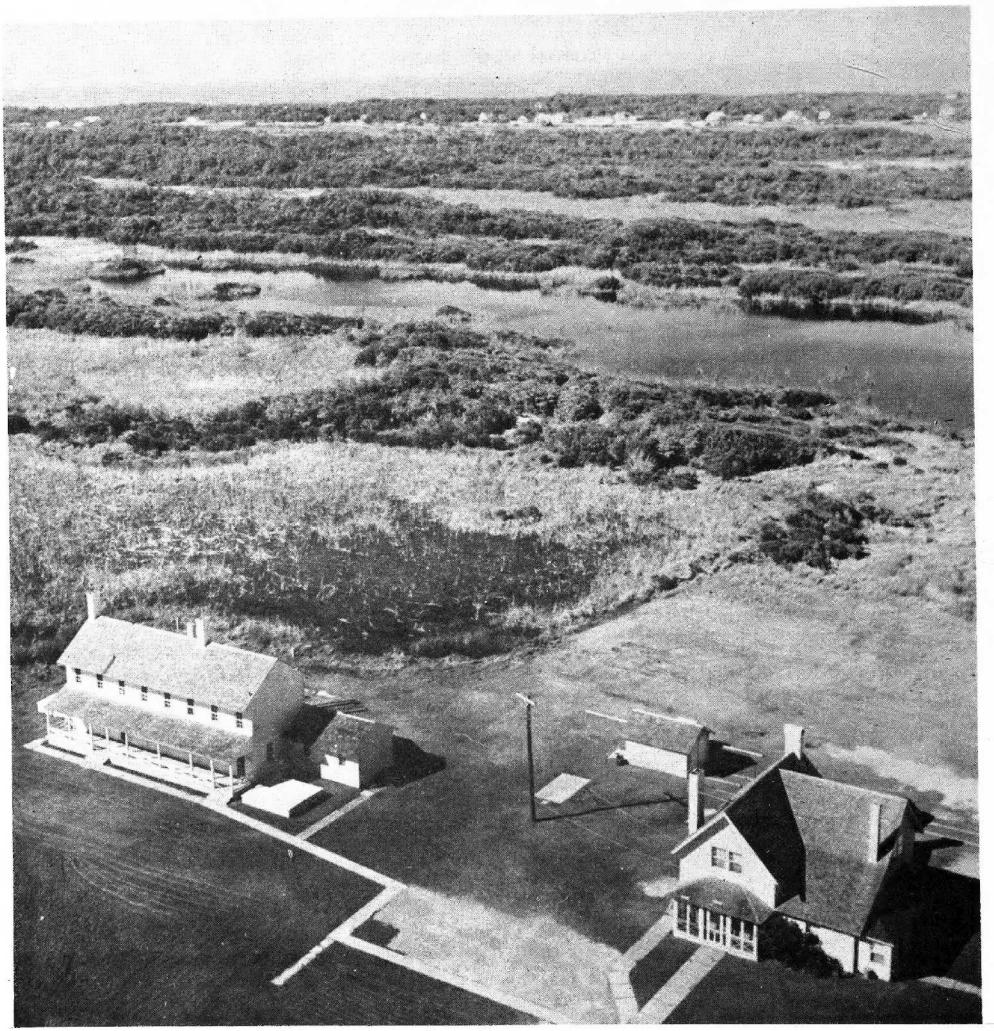
RICHARD J. RUSSELL, General Editor

The Louisiana State University Studies was established to publish the results of research by faculty members, staff, and graduate students of the University. Manuscripts of exceptional merit from sources other than the aforementioned are considered for publication provided they deal with subjects of particular interest to Louisiana.

The Studies originally appeared as a unified series consisting of forty-two numbers, published between the years 1931 and 1941. In 1951 the Studies was reactivated, and is now being issued in the following series: Social Sciences, Humanities, Biological Sciences, Physical Sciences, and Coastal Studies. Other series may be established as the need arises.

The Studies in each series will be numbered only serially, without volume designation.

All inquiries regarding the Studies should be addressed to the Louisiana State University Press, Baton Rouge.



FRONTISPIECE—View from top of Cape Hatteras Lighthouse showing National Park Service Maritime Museum and Ranger Quarters with typical pond and ridge topography in the background.

Copyright 1959

BY LOUISIANA STATE UNIVERSITY PRESS

Library of Congress Catalog Card Number: 58-59768

Lithographed in the U.S.A. by Printing Office of Louisiana State University

PREFACE

In 1954 the Coastal Studies Institute of Louisiana State University contracted to make a comprehensive survey of the Cape Hatteras area of the Carolina Coast. The work was to include the archeology, cultural geography, botany, coastal morphology, and geology of the region. The research was sponsored jointly by the Geography Branch of the Office of Naval Research and the National Park Service.

In December 1957, this monograph was released to a limited distribution list as Technical Report No. 8, Part C, Project No. N7 onr 35608, Task Order No. NR 388 002 of the Office of Naval Research. This present edition is nearly a facsimile reproduction of the Technical Report, entitled "Botanical Reconnaissance of the Outer Banks of North Carolina".

TABLE OF CONTENTS

	Page
ADVANCE SUMMARY	x
INTRODUCTION	1
HISTORICAL	3
A. Botanical Studies on the Outer Banks	3
B. Historical Distribution of Forests	10
C. Sand Fixation and Beach Erosion Work of 1936-40	17
BOTANICAL-ECOLOGICAL RECONNAISSANCE	25
A. Habitats	
Sea Beach	26
Dunes	27
Sand Flats	34
Tidal Marshes	38
Ponds	41
B. Geographic Locations	
Ocracoke Island	44
Roanoke Island	46
Currituck Peninsula	48
Currituck Banks	49
A CENTURY OF CHANGE AT CAPE HATTERAS	55
SALT SPRAY INJURY	62
PLANT MATERIALS FOR SAND BINDING	69
A. Native and Naturalized Plant Materials	69
B. Possible Introductions	80
CATALOGUE OF PLANTS OBSERVED ON THE OUTER BANKS	85
LITERATURE CITED	116

LIST OF PLATES

Plate I. Locality map.
Plate II. Fence types.
Plate III. Types of vegetation zonation observed on Hatteras Island.
Plate IV. Changes in the vicinity of Cape Hatteras light as shown on 1852 and 1872 U.S. Coastal Survey maps.

LIST OF FIGURES

Fig. 1. Stumps exposed north of Rodanthe.
Fig. 2. Cedar stumps at Wash Woods.
Fig. 3. Live oak stump at Wash Woods.
Fig. 4. Live oak skeletons near Avon.
Fig. 5. Type "A" brush panel fence with spur brace.
Fig. 6. Sand trapped in about 3 months time.
Fig. 7. Black locust defoliated and injured by salt spray.
Fig. 8. Pine plantation near Salvo.
Fig. 9. Live sand invading thicket of live oak and wax-myrtle.
Fig. 10. Sand trapped by thicket.
Fig. 11. Blow out after plants of thicket were killed.
Fig. 12. Dissected dunes on Bodie Island.
Fig. 13. Clump of American beachgrass.
Fig. 14. Dune capped with sea oats.
Fig. 15. Dune covered with running beachgrass.
Fig. 16. Section of dune to show how grasses cause dune formation.
Fig. 17. Prostrate live oak dwarfed by salt spray.
Fig. 18. Live oaks showing one-sided growth near Buxton.
Fig. 19. Saw-grass marsh between ridges and around live oak mounds between Buxton and Frisco.
Fig. 20. a. Live oak trunk in sheltered area near base of dune.
b. Tree crowns extending above the ridges are deformed.
Fig. 21. Sand dune invading the forest near Kitty Hawk. Planted with grass to attempt stabilization.
Fig. 22. Sand dune advancing on sound. Nags Head Woods.
Fig. 23. Sand flat near Rodanthe.
Fig. 24. Sand flat near southwest tip of Hatteras Island.
Fig. 25. Sand flat north of Corolla.
Fig. 26. Aerial photo of pond, mounds and sound side dune. Bodie Island.
Fig. 27. Sand trapped by snow fencing north of Corolla.
Fig. 28. Wall of sand trapped between two lines of snow fencing.
Fig. 29. Aerial view across Currituck Banks at Corolla.
Fig. 30. Aerial view of vicinity of Cape Hatteras Light taken 1936-40.
Fig. 31. Aerial view of vicinity of Cape Hatteras Light taken 1946 (?).
Fig. 32. Aerial view of vicinity of Cape Hatteras Light taken 1952.
Fig. 33. Young pine planting at Corolla.
Fig. 34. Live oak and wax-myrtle invading sand flat at Corolla.

Fig. 35. Barrier dune at base of Cape Hatteras Lighthouse from the ocean side.
Fig. 36. View from the top of the Cape Hatteras Lighthouse looking northward.
Fig. 37. View of sand flat southwest of Cape Hatteras Lighthouse.
Fig. 38. Dwarfed tree vegetation on mounds.
Fig. 39. Salt spray pruned thicket of live oak and yaupon.
Fig. 40. Spray trimmed yaupon near Salvo.
Fig. 41. Clump of sea-shore elder on dune.
Fig. 42. Sea oats starting dune formation.
Fig. 43. American beachgrass is an important sand binder.
Fig. 44. Knotgrass forms a dense sod.
Fig. 45. Saltmeadow grass invading beach.
Fig. 46. Spanish dagger is a good sand binder.
Fig. 47. A machine-made dike.
Fig. 48. Purple muhly is a bunchgrass.
Fig. 49. Two kinds of cacti occur on Hatteras Island.
Fig. 50. The beach-holly is a rare adventive which should be protected from extermination.

ADVANCE SUMMARY

I. The major habitats of the Outer Banks are (1) dunes, both grass covered and wooded; (2) sand flats; and (3) salt marshes. Each of these has a characteristic vegetation.

II. The sand fencing, which was constructed in 1936-1940, has been very effective in establishing barrier dunes along the beach. Some of these dunes have been washed away by storms which have also destroyed man-made structures of concrete and steel with equal facility.

III. Grasses, planted in connection with the dune construction, have stilled much of the shifting sand. This brought about an unexpected and rapid invasion of the sand by many native plants that are of secondary importance in sand fixation. The most important grasses used on this project were American beachgrass, sea oats, saltmeadow cordgrass, and Bermuda grass.

IV. Some of the tree planting has not been as successful as the grass planting because of unexpected susceptibility to salt spray injury. The following, although injured at times by the salt spray, have proved to be the best trees and shrubs to use in this area: live oak, yaupon, wax myrtles, silverling, and marsh elder. Maritime pine, a native of the Mediterranean region, was used in limited quantities. It proved to be more resistant to the salt spray than the native pines and should have a wider use.

V. This survey established that there are several additional native plants of primary value and more of secondary value in sand fixation. Some of these are knotgrass, running beachgrass, silver beachgrass, sea-shore elder, gallberry, silverling, and beach heather.

INTRODUCTION

The Outer Banks is the name applied to a group of low-lying, sandy, barrier islands which fringe the coast of North Carolina. They extend from the Virginia State line southward through Cape Hatteras, and Cape Lookout to Cape Fear on Smith Island near the southern boundary of North Carolina. (Plate 1, Locality map.)

The area investigated extends from the Virginia State line southward through Currituck Banks, Bodie, Roanoke, Pea, Hatteras, and Ocracoke Islands and a few selected locations on the mainland. This area was visited four times; namely, October 17 - 19, 1954; April 7 - 9; August 1 - 10, and October 7 - 9, 1955.

The objectives of this survey were as follows:

1. To study the effectiveness of the sand stabilization projects installed by the Civilian Conservation Corps under the direction of the National Park Service between 1936 and 1940.

2. To examine the vegetation and recommend other sand binding plants which could be used in this area effectively.

3. To secure any pertinent botanical-ecological information which had a bearing on the past vegetation history of the area and which would contribute to a better understanding of the problems relating to planting and the natural spread of native vegetation.

Acknowledgements. The writer greatfully acknowledges the assistance of the U.S. National Park Service employees; in particular to Mr. A. C. Stratton, Assistant Regional Chief, Region 1; Mr. Allyn Hanks, Superintendent of the National Seashore Recreational Area; Mr. Verde Watson, Park Naturalist; Messrs. G. S. Hultman, Charles G. Lamb, W. B. Fearing, Hazen Brooks, and B. J. Baum. Likewise Drs. R. J. Russell, James P. Morgan and Martin Wright of the Coastal Studies Institute at Louisiana State University have given encouragement and assistance. Plates I to IV were furnished by the Coastal Studies Institute.

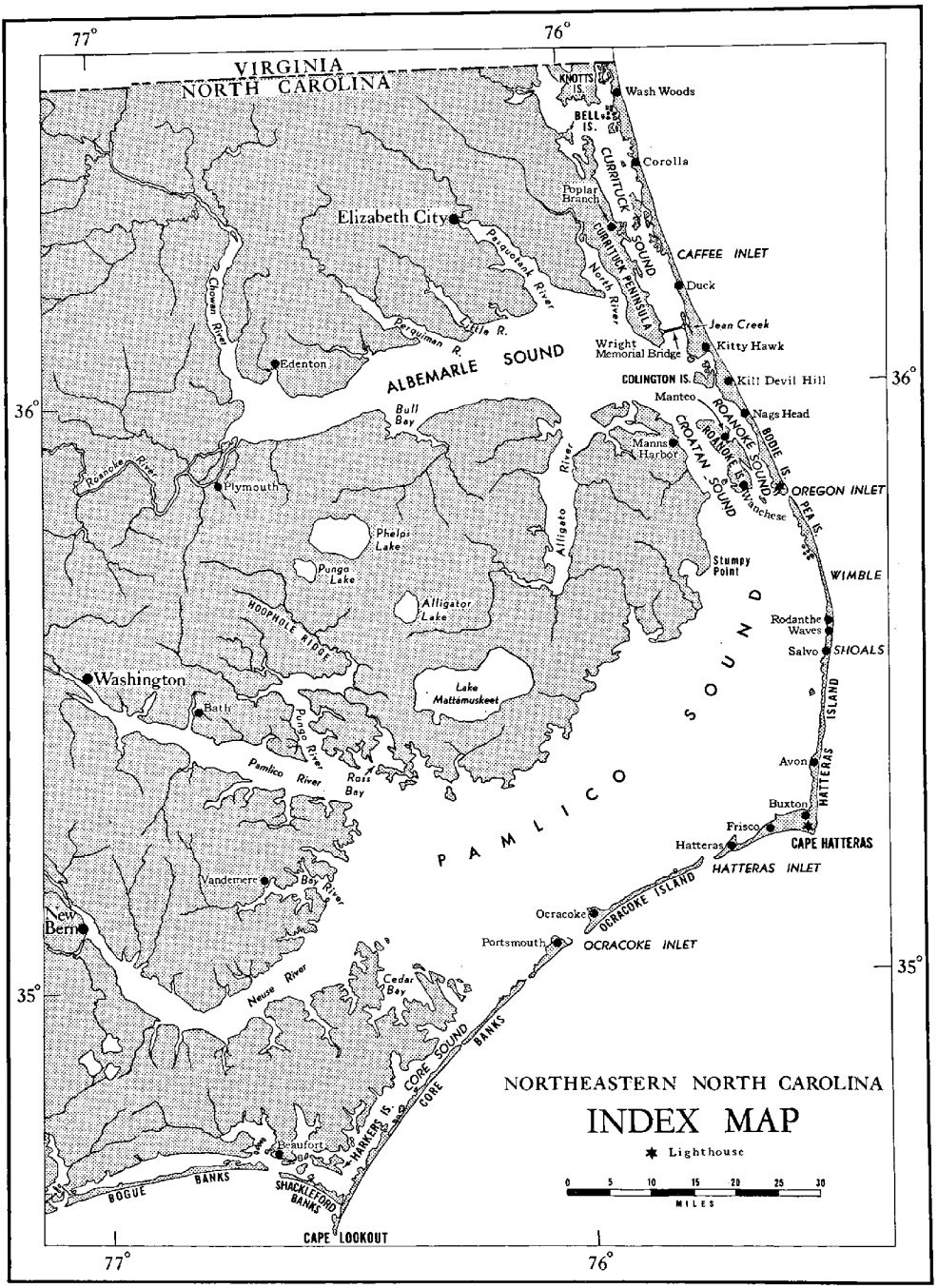

77°
76°
VIRGINIA
NORTH CAROLINA
KNOTTS IS.
Wash Woods
BELL IS.
Corolla
Poplar Branch
Elizabeth City
Pasquotank River
CURRITUCK SOUND
CURRITUCK PENINSULA
CAFFEE INLET
Duck
North River
Joan Creek
Kitty Hawk
Wright Memorial Bridge
Perquimans R.
Little R.
Chowan River
Edenton
ALBEMARLE SOUND
COLINGTON IS.
Kill Devil Hill
Manteo
Nags Head
36°
Bull Bay
ROANOKE SOUND
BODIE IS.
Roanoke River
Manns Harbor
CROATAN SOUND
ROANOKE IS.
Wanchese
OREGON INLET
Plymouth
Alligator River
PEA IS.
Phelps Lake
Pungo Lake
Stumpy Point
WIMBLE
Alligator Lake
HOOPHOLE RIDGE
Rodanthe
Waves
Salvo
SHOALS
Washington
Lake Mattamuskeet
PAMLICO SOUND
HATTERAS ISLAND
Bath
Pungo River
Pamlico River
Ross Bay
Avon
Buxton
Frisco
Hatteras
CAPE HATTERAS
HATTERAS INLET
Vandemere
Bay River
Ocracoke
OCRACOKE ISLAND
New Bern
Portsmouth
OCRACOKE INLET
35°
Neuse River
Cedar Bay
CORE SOUND
BANKS
HARKERS IS.
NORTHEASTERN NORTH CAROLINA
INDEX MAP
Lighthouse
0 5 10 15 20 25 30
MILES
Beaufort
BOGUE BANKS
SHACKLEFORD BANKS
CAPE LOOKOUT

Plate I

HISTORICAL

A. Botanical Studies on the Outer Banks

This interesting area has received very little attention from botanists. There is so little mention of the vegetation in the early historical accounts of this region that some have interpreted this lack of printed or manuscript records of the flora as indicating an absence of vegetation.

Price (1795) contributed one of the earliest notes. He wrote:

> Small live oak and cedar grow abundantly on it; and it contains several swamps and rich marshes, which might be cultivated to great advantage; but its inhabitants, depending upon another element for their support, suffer the earth to remain in its natural state..... Cape Hatteras and the land from it towards Occacock [Ocracoke], to the distance of about thirteen miles, are covered with large evergreen trees, such as live-oak, pine and cedar. Here are three large and remarkable sand hills called Stowe's Hills [Styron Hills]. The coast afterward is a bald beach, interspersed with a few low sand hills; about eleven miles farther is a group of trees, called six-mile hammock, from its distance from Occacock [Ocracoke] - from thence the coast is quite barren and sandy.

Welch (1886)obtained the following information from natives of Hatteras and Ocracoke Islands. The area was wooded, mainly with yaupon and live-oak. There were a few homes in the neighborhood. Following the night of the hurricane's passage (Sept. 7-8, 1846): "In the morning they saw the sea and sound connected together, and the live oaks washing up by the roots and tumbling into the ocean."

Pinchot and Ashe (1897) wrote as follows:

> In places along the coastal islands, and this is particularly true to the north of Cape Hatteras, there are great stretches destitute of all tree growth, the soil being coarse beach-sand, the surface of which rises into parallel ridges which reach a height, in places of 70 or more feet above sea level; and this sand, being fixed by no network of plant root-fibers, and containing no binding ingredient,

> is constantly shifting under the impact of the winds. Some such areas were originally forest-covered, but are cleared, and the humus, which was slightly cohesive, destroyed, the constant movement of the sand before the winds, which here piled into shifting dunes, has prevented a general growth of any kind from securing a foothold. Fishermen's houses have been destroyed by these moving dunes and their sites obliterated, and others are menaced by them.

Thomas Kearney (1900) was the first botanist to make a study of the vegetation of Ocracoke Island. He spent five days there and listed 136 species for the Island. He prepared a discussion of the plant associations under the following outline:

I. Sand-strand vegetation
  1. Treeless (open)
    a) Beach formation: Croton-Physalis association.
    b) Dune formation: Uniola-Yucca association.
  2. Evergreen trees and shrubs
    a) Tree formation: Quercus virginiana association.
    b) Thicket formation: Ilex vomitoria association.

II. Salt-marsh vegetation
  1. Creek marsh (close) formation.
    a) Spartina stricta association.
    b) Juncus roemerianus association.
  2. Dune-marsh formation: Lippia-Monniera association.
  3. Tidal flat (open) formation: Sesuvium-Tissa association.

III. Pastures and ruderal plants.

IV. Cultivated plants.

He made the following notes concerning the trees:

> Scattered over the island, but preferring the higher dunes which occupy its side, are small groves of live oak, (Quercus virginiana)=(Q. virens), either in pure association or mixed with some other trees. The oaks are usually 6 to 9 meters high and 3 (rarely 7-1/2) decimeters in diameter ..... All the specimens of live oak seen were apparently of considerable age. Seedlings were few or none, and no acorns were observed. It is probable that instead of increasing, the oak is here holding its own with difficulty, so highly are the trees valued as wind-breaks by the inhabitants that none are felled, all fuel being brought from the mainland.

Johnson (1900) spent three weeks studying the vegetation on Bogue and Shackleford Banks (Plate I). He contrasts the difference between these two islands as follows:

> Bogue Bank, at the point studied, seems to have reached a

stage of development where it is comparatively stable. It has an outer border, or sea wall as it were, of high dunes covered with Andropogon maritimus and firmly bound by its long tough rhizomes into barriers very resistant to the destructive forces of both the sea and wind. On these dunes growing with the Andropogon and within easy reach of the spray, are found scattered scrubby specimens of Juniperus Virginiana and large patches of Ilex Cassine, both overrun with Ampelopsis quinquefolia, ...

On the latter bank [Shackleford] instead of the outer border of comparatively stable dunes, we find a shifting waste of windblown sand, stretching in a quarter of a mile or more from the water's edge, and reaching its greatest height on its inner border, where it is encroaching upon and rapidly burying what remains of the forest that once covered most of the banks.

At the inner edge of this shifting sand plain, its surface is often ten or twelve feet above the old forest floor upon which it is advancing. It ends abruptly in a steep slope down which its sand rolls after being blown along the surface of the plain.

From the foot of this slope to the inner or sound side of the bank, a distance of nearly a mile, the surface is rolling and well covered with a thick scrubby forest, made up chiefly of Quercus virens, Quercus aquatica, and Quercus nigra with Ilex opaca, Morus rubra, and Persea Carolinensis, Carpinus Caroliniana, Juniperus Virginiana, and Pinus Taeda. The highest of these trees near the middle of the bank reach a height of twenty-five or thirty feet, some of the pines perhaps exceeding this limit in the wider part of the island.

Coker (1905) visited Smith Island near Cape Fear and noted:

The island is covered thickly, except for the dunes, with arborescent growth of low to medium height ..... In the forest which covers the whole interior of the island the trees are of vigorous growth, reaching a height of thirty to forty feet. The pines (Pinus taeda) and oak (Quercus virginiana and Q. laurifolia) are the dominant forms.

Lewis (1917) visited the same islands as Johnson and wrote the following account of his visit:

Passing through this area [Shackleford Bank] toward the sea, one comes on an advancing sand wall, 10 to 20 feet high, which is burying the vegetation at a rapid rate ..... Besides these remnants of a once vigorous forest growth, there are present on the sandy plateau between the thickets

> and the sea only a few scattered specimens of the species usual on the outer beach. The shifting soil is no doubt responsible for the sparseness of the living vegetation.
>
> East of High Hill [Shackleford Bank] the ground is uniformly high, from 10 to 20 feet above sea-level, and the sand strand is quite narrow. In this stretch occurs open woodland, where the vegetation is not so dense as in the thicket woodland farther west. The characteristic trees are Quercus virginiana, Q. phellos, Persea pubescens, Morus rubra, and Ilex opaca. From this point (Wade's shore) to Cape Lookout both forest and swamp have disappeared completely save for one or two small groves of live oak, which have been able to resist the advancing sand. Elsewhere this portion of the island is a sandy waste, with little or no vegetation, except that in the lower places may be seen evidences of the swamps that existed here before the advancing sand covered the island from the sea to the sound.
>
> In the memory of living inhabitants, the Bank (Shackleford) was well wooded over its entire extent, the strand separating the forest from the ocean being so narrow that it was 'possible to sit in a tree and cast a fishing line into the water'. Before the Civil War, however, cutting of timber, coupled with forest fires, and the grazing of cattle and sheep, and the inroads of gales, had broken the protecting wall of vegetation and allowed the sand from the beach to blow in on the trees. Slowly at first, and then more and more rapidly, sand was blown in on the vegetation, killing or covering the existing plants.

Wells and Shunk (1938) observed on Cape Fear Peninsula that the deformed trees usually designated as "wind-swept" had actually assumed their peculiar shapes as the result of salt spray which killed the buds and tender leaves on the windward side. Wells later (1939) expanded his studies on the effect of salt spray on the vegetation. He came to the conclusion that the maritime forest in which live oak is the dominant species was formed when the salt spray killed off susceptible species, thus leaving the live oak community as the climax vegetation for the Outer Banks. His views are clearly stated in the following quotation:

> The entire two-thirds of this 'main island' [Smith Island, Cape Fear] is covered with a unique forest of live oak (Quercus virginiana) - unique in the sense that this tree here forms a practically pure stand with the crowns meeting (fig. 2), except for an occasional palmetto (Sabal palmetto) ..... Earlier there was a second important tree, though

not to be regarded as subdominant; viz., the red cedar, (Juniperus virginiana). This was cut extensively in the past leaving the oak to assume an unusually high degree of dominance. These oaks today give every evidence of being climax. Very old, living trees with trunk diameters of 3-4 feet are frequent, and scattered in them one encounters disintegrating trunks of even larger trees. In addition to this direct evidence a report on the island made in 1805 by J. G. Smith, an officer in the U. S. Army, states concerning the growth of the Cape Fear River: 'On Smith Island there is a quantity of live oak and palmetto.' There can be no question of the climax status of this forest.

Engels (1942) spent 36 days on Ocracoke Island in different seasons studying the fauna. Although he did not make a list of plants, he does mention many in his accounts of the habitats of the animals. He collected specimens which were identified by Laurie S. and Albert E. Radforth and which have been deposited in the herbarium of the University of North Carolina. Engels mentioned briefly the effect of storms on vegetation and cites an example of a wooded thicket which disappeared completely in a period of nine years, largely as the result of its reaction to the violent storms of 1933 and 1937.

Egler (1942) studied the vegetation of the Seashore State Park at Cape Henry, Virginia, an area analogous to the Outer Banks of North Carolina. He collected 336 species in the park which has an area of 3,437 acres. The following is an outline of the zones and communities that he recognized:

1. The Ocean Zone
2. The Beach Zone
   - Lower beach, barren
   - Middle beach, occasional stray plants
   - Upper beach, The Panicum-Ammophila Community.
3. The Salt-spray Grassland Zone.
   - The Uniola paniculata Community
4. The Salt-spray Scrub Zone
   - The Quercus cinerea Community
   - The Juncus Community
   - The Typha Community

5. The Forest Zone
   - The Pinus-Quercus Community
   - The Pinus-Myrica Community
   - The Gaylussacia-Castanea Community
   - The Pinus-Quercus-Carya Community
   - The Taxodium-Nyssa Community
6. The Tidal Marsh Zone
   - The Spartina patens Community
   - The Spartina alterniflora Community
7. The Bay Zone.

It is interesting to note that Egler states that the Quercus cinerea Community covers at least 95% of the Salt Spray Scrub Zone. This community appears to be absent from the Outer Banks in that this particular species was found only at Fort Raleigh on Roanoke Island. He recognizes a Pinus-Quercus Community in which the important dominants are Pinus taeda, Quercus cinerea, and Quercus virginiana. He characterizes the ridge and swale land behind the great dune as being covered with a Pinus-Quercus-Carya Community in which loblolly pine, virginia pine, live oak, white hickory, post oak, southern red oak, beech and red maples occur on the ridges with sweet bay, redbay, and holly in the moist swales between the ridges.

The studies of Oosting & Billings (1942) on Bogue Bank were concerned with the environmental factors which influence plant distribution. They found salt spray active in zoning the plants with sea oats dominant where the salt spray was the greatest. Oosting (1945) sprayed sea water on some 15 species of strand vegetation. He concluded from the results that most strand species are relatively tolerant to salt spray and injuries or death occurs among the least tolerant.

Engels (1952) visited Shackleford and Bogue Banks. He compared the U. S. Coast Survey maps of 1851-53 with the U. S. Coast and Geodetic Survey manuscript drawn from aerial photographs made in 1946 and revised in 1949, and made the following summary:

> Whereas the woodland is now confined to a relatively narrow strip between The Mullet Pond and Whale Creek Bay, in 1851-53 virtually the entire island, except the salt marshes was heavily wooded. On the westward third of the island, the woods extended beyond the Mullet Pond towards Shackleford Point, and from the sound to the ocean. Eastward from Whale Creek Bay, there is now an unbroken grassland, devoid of even brush, the woodland extended all the way to the tidal flat westward of Cape Lookout. That this is a real woodland, and not merely a grassland interrupted by thickets, is evidenced by the conspicuous labelling of this area on the old charts as 'Lookout woods'.
>
> From these surveys, mapped on a scale of either 1:10,000 or 1:20,000, it is possible to calculate the area extent of the woodland with a reasonable accuracy. In 1851-53, the wooded area occupied about 1250 acres, roughly 2 square miles; of this, in 1948, only 180 acres, or about 15 percent, remain. Eastward from Whale Creek Bay, in 1851-53, Lookout Woods covered about 400 acres; now, with minor exceptions of Sam Winters Lump and Bells Island, neither of more than 1 acre, Lookout Woods has disappeared completely. Not a single tree remains. In its place is a grassland, which is invading the salt marshes bordering the sound, as the level of these is raised by the blow-off of sand from the upper part of the ocean beach.
>
> From Whale Creek Bay to The Mullet Pond the immediate cause for destruction of the forest, whatever the initiating factors, is clearly evident, since it is still at work. Here a wall of sand is advancing across the island, literally burying the woodland as it creeps along .....

Engels also expanded the discussion and presented considerable data to show that tropical storms, striking the Outer Banks, and subsequent flood waters are more destructive to the vegetation than is the effect of human activities, as is popularly believed.

Miss Katherine Rondthaler spent part of the summer of 1951 studying the vegetation of Ocracoke Island. Her results, well worthy of publication, were recorded in a Bachelor's thesis submitted to Reed College, Portland, Oregon. She listed 106 species for this island and recognized the following habitats:

I. SAND STRAND VEGETATION

Fore dune
Beach proper
Back of the beach
Dune
Thicket and Woodland

II. MARSH VEGETATION
Salt marsh
Creek marsh
Tidal marsh

III. ROADSIDE AND FIELD.

Boyce (1954) investigated many phases of salt spray on plants, not only on the Carolina coast but also on the New England coast. He found salt spray intensity varied with wind speed and distance from the coast, and increased abruptly when the wind velocity reached seven meters per second which was the speed at which whitecaps formed. He attributed necrosis and death of tissue to the accumulation of chloride ions in the plant. Also plants with abrasions from wind-lashing or sand-blasting absorbed greater quantities of salt spray than those with intact foliage.

Oosting (1954) published an excellent review of the literature on the ecology of the maritime strands in the southeastern United States. He summarized the classification of the plant communities and environmental factors which effect the vegetation.

B. Historical Distribution of Forests

The original vegetation on the Outer Banks, in particular, whether or not there were any forests and their extent, is an item of interest to many. There seem to be two main concepts. The first is that the Outer Banks were densely wooded when the first white settlers arrived and that man has cut and removed the timber. Subsequent vegetation was destroyed by fire or by overgrazing which in turn destroyed the protective root mat which held the sand in place and allowed the development of live dunes. These sand dunes spread slowly across grasslands and forests, leaving a sand barren in their

wake. The other concept was that, with a few exceptions of specific wooded areas, the Park portion of the Outer Banks was treeless. Each view has many adherents today, who cite examples within the memories of older inhabitants to substantiate their beliefs.

Charles W. Porter, Historian of the National Park Service, wrote a departmental report based upon his study of a series of maps which date from 1585 to the present. He expressed the opinion that the tree symbols of the early maps were a matter of real estate propaganda to entice the European settlers to come to the area, and concludes that, aside from Colington Island, Nags Head, and Buxton Woods, most of Bodie and Hatteras Islands were treeless.

There are legends, widely repeated, that in the Rodanthe area, a forest extended from the Atlantic beach to the sound during the Civil War period. Today most of this area is without a tree. A few moderately large live oaks exist in discontinuous clumps along the sound side from Avon to Rodanthe (Plate I). There are several live oak stumps in this region which are not associated with any tree vegetation.

Several articles featuring the Outer Banks have appeared from time to time in the National Geographic magazine. Although the writers tend to glamorize their subject, the illustrations used for these accounts give some information as to the vegetation.

One of the oldest accounts about Cape Hatteras in the Geographic is by Collier Cobb (1906). He cites dune movement from Currituck Banks southward. The following quotations give his views:

> These wind ripples, started in sands exposed by the removal of a strip of forest next the shore, have grown in size to great sand waves .....

He mentioned that a hotel and two cottages at Nags Head had been engulfed;

also a fishing village on the north end of Hatteras. He dated this as follows:

> The movement of sand was started just after the Civil War by cutting of trees next the shore for ship lumber, and the section is still known as The Great Woods, though not a stick of timber stands upon it today.

He mentioned a similar forest on the high dune to the southwest of Cape Hatteras which had a palmetto swamp between the dunes. He apparently did some of the early tree planting as can be seen by the following statement:

> In Jan. 1886, the writer planted the seed of loblolly pine on the back of a dune and covered the area with bush cut from a nearby road in the process of making ..., and today there is a forest of several acres where twenty years ago was a moving sand waste.

Blanche Nettleton (1933) served as a physician for several years in this area. She published a well-illustrated, interesting article in the Geographic. The Cape Hatteras Lighthouse is shown in a photograph on page 694 with a part of a U-shaped, metal groin showing. There is no vegetation in the illustration. She commented on the fact that, when the lighthouse was constructed in 1870, it was nearly a mile from the beach but, in 1933, it was only 100 yards from it. Photographs of beach scenes on pages 706 and 710 do not show dunes or plants. The photograph taken on Shackleford Island, page 707, shows a wooden fence, used to stop sand movement and the remains of a buried forest. This is a U. S. Geological Survey photograph. The photograph on page 709 shows sand invading the forest vegetation on Kill Devil Hill. She wrote (p. 713)

> There is no road, we rolled twisting down the little snake-like 'lands' which separate the home plots; also harboring the family graves and on to the piney ridge.

A photograph at Rodanthe, page 721, shows no vegetation in the background. Stratton and Hollowell mention legends of a dense strip of woods, more than a half mile wide, at Rodanthe during the Civil War; today this is non-existent.

The Bodie Island Lighthouse is shown on page 730. A few shrubs and some grass are visible in the illustration. Today there is a heavy growth of shrubs around this lighthouse, enough to nearly hide the adjacent living quarters.

Guild and Fletcher (1947) give several references to the vegetation in the Cape Henry area. A photo on page 335, taken at Oregon Inlet, shows a dense growth of marsh vegetation and a few little shrubs. An aerial photo taken near Nags Head and reproduced on page 338 shows high tide flooding the low parts of a residential area. Large dunes nearby are capped with grass and shrubs.

Hurricane "Connie" passed by Hatteras in the period between August 9 and 14, 1955. The waves moved great quantities of sand and exposed an area of beach, thickly set with stumps, a few miles north of Rodanthe. These stumps were reburied by hurricane "Diane" a short time later. Figure 1 shows some of these stumps. Dr. J. P. Morgan collected six wood samples and microscopic examination showed them to be a southern yellow pine. These stumps were reasonably sound but samples from the buried peat near Durants were fragile, checked excessively on drying, and appeared to be distinctly older.

The preceding historical discussion carried statements by Lewis, Johnson, and Engels concerning the forest cover for the southern portion of this island chain. They each indicated that the forest was quite widespread in the early 1800's for their respective areas. Thus the present lack of trees in the central and northern portion of the same island chain suggests that possibly there once were forests there too, which were subsequently destroyed.

Engel's (1942) concept that the forested areas on the Shackleford

Banks have been excessively reduced is based upon his interpretation of the symbols on the 1851-53 maps. He believed that they indicated forests. There is no key or legend to the symbols and it is probable that they indicated an area covered with woody plants, part of which were forest trees and part, in the area closest to the beach, may have been a shrub thicket.

Although it is not possible to settle the controversy on the basis of this reconnaissance, the following evidence and interpretations favor a more extensive forest than exists today, although not a complete coverage of the Outer Banks.

Gary Dunbar (1956) found historical records that the banks were used for cattle grazing as early as 1694, and many additional records from that time through 1776. It is obvious that the banks would not have been considered good grazing lands if they had been wooded from the sound to the Atlantic. Wells and Shrunk (1938) report the zone of salt spray toxicity from 0.1 to 0.3 miles in width and 1.35 miles at Kitty Hawk. This effectively indicates a zone of grassland between the beach and the woodland in the center of the islands. Although salt marsh vegetation would furnish grazing when the plants are young and tender, they would not be as palatable when mature as the vegetation of the sand flats. Thus the historical records on grazing, coupled with the toxicity of the salt spray, suggests the presence of a narrow band of grassland.

Close to the Virginia-North Carolina line is an area of exposed stumps known as Wash Woods. Three main groups of stumps are exposed, most of which are located in the zone between low and high tide. The stumps are of redcedar, live oak, red mulberry, and one of cypress. (Figs. 2, 3). One historical account, which probably applies to these trees, indicates that they were living trees in 1812. (See page 51).

There are also live oak stumps and skeleton trees along the sound between Little Kinnakeet Coast Guard Station and Rodanthe on the sound side of Hatteras Island. This certainly suggests that conditions for forest growth were favorable at one time. (Fig. 4). The U. S. Coast Survey maps from 1850 to 1870 bear survey station names such as Palmetto, Old Tree, Cedar Hammock, Cedar Point, Cedar Island, Myrtle Signal, which suggest that trees once existed in areas that are now barren.

It is well known that many inlets have opened and closed in the region from the state line to the tip of Ocracoke. The dates of opening and closing of several of these is accurately known. Caffee Inlet was closed about 1800 and New Inlet between Pea Island and Hatteras has opened and closed several times. Obviously inlets of such recent origin were not wooded and have not had time to develop forests since their closing.

It is the writer's concept that forest as such covered a much wider area in years past than they do today. These forests consisted of trees of medium to large sizes. It seems doubtful if forests of this category extended from the edge of the marshes on the sound side to the high tide line on the Atlantic side. It is reasonable to assume that the Atlantic side consisted of a low, barren beach subject to periodic tide flooding and thus was not suitable for vegetation. A little farther inland, a few small dunes were scattered in the grass-covered sand flats -- a meadow into which the forest was slowly advancing. This was a tension zone, occupied by dwarfed forest trees and shrubs (shrub thicket), the ever present salt spray being the controlling factor.

Pine stumps under the beach near Rodanthe and live oak-redcedar-cypress-mulberry- stumps in the surf at Wash Woods should not be cited as forests growing at the margin of the Atlantic, but as relic forests

which gradually succumbed as the Atlantic advanced. These stumps are now in a location where their respective species cannot grow at present. These trees must have started under much more favorable conditions than exist today and which persisted long enough for the trees to attain fair size. Three or four factors, each alone or working together, could be responsible for the presence of the stumps in these locations. They must have started growth some distance from the sea, perhaps behind a protective dune, and beach erosion over a period of several centuries washed away the intervening land, leaving them in their present location. This process could also explain a sound to sea forest cover prior to the death of the trees from injury by salt water spray and flooding.

The theory has been advanced that the Outer Banks are gradually being moved westward by winds which carry the sand from the Atlantic Beach across the Island and dump it into the Sound. This gradual westward migration of the land could thus leave the trees which once grew near the center of the Island on the margin of the sea.

A rise in sea level, which is taking place along the Atlantic seaboard at about one foot per century may be an explanation. Subsidence, or sinking of the land could produce the same result as a rise in sea level. The drowned stream valleys on the adjacent mainland is ample evidence to indicate sea level changes.

It seems probable that there is a correlation between the location of village sites and the presence of forest vegetation. Trees played an important role in the life of the early settlers. They furnished shade, shelter from the winds, fuel, lumber for their homes and boats, and a cash crop for the harvesting. It is therefore reasonable to expect that homesites would be chosen with a view to the availability or accessability of trees.

C. Sand Fixation and Beach Erosion Work of 1936-40

Review of a report by A. C. Stratton and James R. Hollowell, "Sand Fixation and Beach Erosion Control," July, 1940. U. S. D. I. National Park Service. 87 typewritten pages and 32 illustrations.

The history of Cape Hatteras and its description is briefly reviewed in the first ten pages. The outstanding feature of this portion is the mention of extensive forests on various parts of the island. The authors trace the change from restricted to unrestricted grazing, along with the utilization of trees which together resulted in the destruction of vegetation cover allowing the unprotected sands to move freely. They also cite changes in boating, fishing, oyster production, and the abandonment of private hunting preserves following the erosion of land. They describe the activities of one club superintendent who constructed brush fences from young, nearby pines and planted "Cape Cod grass" to protect the hunting club property.

The balance of the report is concerned with research on sand movements, different types of sand fencing constructed, plant materials used, and costs. The following is an abridgment of the pertinent information. Brush panel construction was more effective for sand fences than were vertical slabs or jute bagging and thus was used extensively. These panels were constructed by placing two battens parallel on a table with the outside edges 24 inches apart. They were covered with brush and two other battens were nailed to the first with 20d nails. The brush was then trimmed to a length of 36 inches, thus completing the panel. These panels were fastened to posts in six major patterns (Plate II). Type A consisted of a straight fence with alternating panels on opposite sides of the posts. This was braced with a spur panel at right angles to the

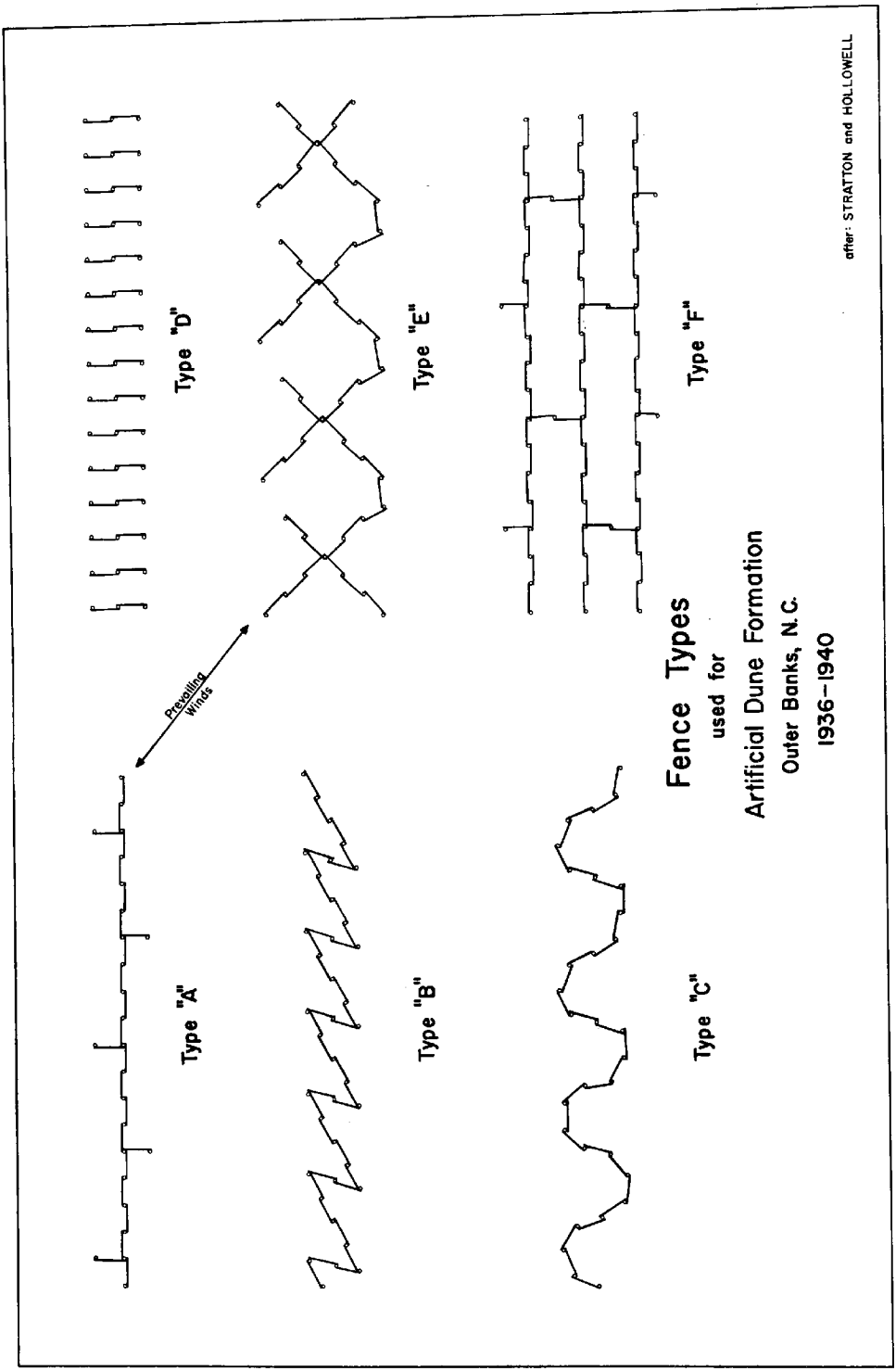

Type "A"
Type "B"
Type "C"
Type "D"
Type "E"
Type "F"
Prevailing Winds
Fence Types
used for
Artificial Dune Formation
Outer Banks, N.C.
1936-1940
after: STRATTON and HOLLOWELL

Plate II

fence. This was the construction most generally used (Figs. 5, 6).

In Type B the panels were arranged in a saw-tooth pattern. This style fence was used in connecting small dunes. Also, it was used specifically "from the Wright Memorial Bridge road northward to Pine Island Club, a distance of about 15 miles; and that area from Whalebone service station southward to Bodie Island Coast Guard Station, about 6 miles."

Type C consisted of an arrangement of undulating bays - a corrugated pattern. This fence was erected back from the main line of fence along the fore shore. It was placed close to grassy areas as it protected the grass and allowed it to volunteer further.

Type D was formed by a series of parallel sections, two panels long, open front and rear. Only a short section of this type was built because of high construction costs.

Type E was a series of interlocked squares with one side partly open, similar to a row of link chain fence.

> This was built at 'The Plains' on Ocracoke Island for a distance of about a half mile. The Plains is an area flooded by sound tides brought in by northerly winds. Therefore a low dune with a broad base was desirable rather than a narrow dune with great height ..... It proved successful during the storm that visited the area on Sept. 21, 1938.

Under the section headed "Accomplishments" is reported fabrication of 3,166,312 feet of fencing, and the erection of 2,945,394 feet of fence. The effectiveness of these fences is shown by three representative cross sections (Figure 29, Stratton & Hollowell), which show changes in profile and thickness of the trapped sand in the four year period.

The planting program was extensive. Some 2,552,359 trees and shrubs were planted along with enough grass to protect 141,841,821

square feet of ground (3,254 acres). All plantings were restricted to indigeneous species. The following is a list of the woody species planted:

Loblolly pine	Pinus taeda
Black locust	Robinia pseudoacacia
Flowering dogwood	Cornus florida
Blackjack oak	Quercus marilandica
Mockernut hickory	Carya alba
Live oak	Quercus virginiana
Water bush	Iva frutescens
Silverling	Baccharis halimifolia
Black willow	Salix nigra
Eastern red cedar	Juniperus virginiana
Callicarpa	Callicarpa americana
Red bay	Persea borbonia
Longleaf pine	Pinus palustris
Shortleaf pine	Pinus echinata
Red maple	Acer rubrum
Red gum	Liquidambar styraciflua
Persimmon	Diospyros virginiana
Bald cypress	Taxodium distichum
Wax myrtle	Myrica cerifera
White oak	Quercus alba

Yaupon, although not included in this list, was evidently planted, because it is mentioned in the tables which discuss the mortality and survival for different sites and planting dates. It is possible that no distinction was made between the two wax myrtles as Myrica pensylvanica is abundant in some of the planted areas.

The presence of extensive, level, barren sand is documented by their figures 11, 12, 13, 21, and 30. Figures 14, 15, 16, and 17 show that some stabilized sand dunes existed, and these were covered with either grasses or dwarfed trees and shrubs. These grass-covered dunes were the source of the beachgrass and sea oats used for planting.

Permanent survey markers were set every half mile. Profiles were surveyed across the island before planting and, in many instances, after planting. The engineering notebooks connected with the project have been deposited recently at the Park Service Headquarters on Bodie Island.

I had access to this report at the time I was examining the vegetation

and sand dunes on Hatteras Island. The report pictured many parts of the ocean side of the island and adjoining islands as consisting of a non-stable, sand desert, so low that ordinary storm tides frequently washed over various parts of the island. It stated that the sound side was covered with a relatively worthless growth of salt marsh plants such as saltmeadow cordgrass, Spartina patens; and black rush, Juncus roemerianus. A few more-or-less stabilized dunes, covered with either sea oats or beachgrass or dwarf trees, existed in some sections. The sand flats were so overgrazed that they were essentially bare of palatable plants.

Today one can see mile after mile of beach fringed with a fixed barrier dune which, for the most part, is covered with a stand of American beachgrass or sea oats. Many of the inter dune flats and secondary dunes are covered with a variety of plants. When one compares Stratton and Hollowell's description and photographs of this area as well as older photographs, with the present conditions, it is very evident that the effort and money spent on this project have produced very worthwhile results. Although the dyed-in-the-wool fisherman will go wherever the fishing is good, the changes produced by this project have gone a long way, not only in making the island a vacation center, but also in encouraging the establishment of permanent habitation.

Unfortunately, the only mention of sand fence locations of several different types occurs in a few generalizations connected with descriptions of the fence types. If the engineering field notes give any information as to the kind of fence or its structural arrangement for specific areas, this should be located in order to evaluate the effectiveness of particular types of construction. Perhaps some of

breakthroughs or washouts could be correlated with the type of fence construction.

A careful examination of the aerial photos of the 1936-40 and 1946 period shows the location of sand fences and the type of construction. Photo No. 07184 covers the southern end of Bodie Island to Oregon Inlet. It is possible to detect three lines of fences which parallel the arc of the Atlantic side flanking the Inlet. They appear to be Type A fence for the most part. A segment of the innermost fence of Type B is visible and, a little farther north in the same photo, one line of Type A is visible.

Photo No. 01788 of Pea Island shows one line of Type A fence running into or back of a discontinuous row of natural dunes. These little dunes have three or four dark spots on their tops, very suggestive of shrubs such as those on the flat-topped dunes in the vicinity of Cape Hatteras Lighthouse. The photo shows one fence parallel to the Atlantic, in the vicinity of New Inlet. There is a V-shaped fork near the Inlet. Northeast of that is a U-shaped fence which touches the straight fence parallel to the ocean. On the south side of the Inlet a fence starts at a bridge on the south branch of the Inlet and runs parallel to the branch, then to the Inlet proper and turns to follow the Atlantic beach southward. All of this fence is apparently Type A. South of the present Pea Island Coast Guard Station, a strip of dune is forming between the ocean and a stretch of Type C fencing.

Photo No. 10172, opposite the town of Waves on Hatteras Island, shows two lines of Type A fence close to the shore and back of them, a Type C fence. Other photos, such as the one in the vicinity of Nags Head, show several lines of Type A fence. A more detailed study of these aerial pnotos will reveal more information about the fence types and their locations.

If the areas of breakthroughs could be plotted along with the type of fence used and its location, it is possible that information could be obtained which would aid in future work.

It is a pity that this valuable work has not received the recognition it deserves*. There are numerous articles on sand dune fixation, but practically no mention of the work on the Outer Banks. It would be worth while for the Park Service to prepare a publication to show what has been accomplished.

It is also very unfortunate that funds and labor have not been available for maintenance work for the past ten to fourteen years. Part of the deterioration of established dunes is caused by man's destructive action. There seems to be a relation between places where barrier dune is highly dissected and the frequency with which man visits the area. There are numerous small dunes near the former Coast Guard Station on Bodie Island, just north of the present Park Service Headquarters. These may be the result of uncontrolled crossing of the dunes with automotive equipment. Once the grasses are crushed down or partly killed, the wind etches away the sand and the gap continues to increase in size. As soon as the sand gets too loose or too deep for a car, another crossing area is selected.

The failure of the dunes by blow-outs or break-throughs for one cause or another should not condemn the fine work of 1936-1940. Why should one expect plants to withstand the forces which so easily destroy man-made reinforced concrete piers and breakwaters?

---

*Stratton, A. C. (1943) Reclaiming North Carolina Banks. Shore and Beach 11, No. 11: 25-27, 32.

Also a popular account of this valuable work was written by G. S. Wells in 1954.

It is interesting to learn something about the fate of the large quantity of trees and shrubs used in the planting program. One or more fires have destroyed a considerable portion of those planted southwest of the Cape Hatteras Lighthouse. Only an occasional pine survives in this area today. The fire-blackened skeletons show that the pine had attained fair size before the destructive fire occurred.

The black locust planting across from the tourist court near the entrance to Buxton Woods is nearly dead (Fig. 7). The quantity of dead branches and small size show that this species is not suitable in this area and should not be used in future plantings. The existing foliage showed considerable salt spray injury which may be the reason the plant has grown so poorly. This species, between Southern Shores development and Nags Head, had good foliage in August, 1955, prior to hurricane "Connie".

The largest surviving pine plantation is a block of pine nearly a mile long near Salvo (Fig. 8). These trees show an interesting crown profile. Near the road the trees are low, about six feet tall, and they gradually increase in height away from the road until they finally level off at a uniform height. This profile is related to the toxic effect of the salt spray. These pines showed brown needles, presumably injury from hurricane "Carol" (1954) and blanched, white needles, probably from hurricane "Edna" (1954). Numerous dead branches showed that buds had been killed in the past. The 1955 storms have also taken their toll.

BOTANICAL-ECOLOGICAL RECONNAISSANCE

This preliminary botanical-ecological survey was sufficient to allow the recognition of the characteristic species and correlations of the major plant communities with their respective habitats. Such factors as moisture, salinity, elevation, proximity to beach, wind exposure, and the activities of man and grazing animals are responsible for the delineation of the habitats and vegetation assemblages. The distribution of the species shows that these habitats often grade into each other and their separation is arbitrary at times.

Visits to the Outer Banks were especially well timed for the writer to see the effects of salt spray on the vegetation and the damage done by hurricane tides. Visits were made after the three hurricanes of the 1955 season and preceding the three storms in 1956 as well as one visit after the 1956 storms.*

The following outline gives the major habitats for the area of the Outer Banks covered by this survey. Detailed studies would result in more and perhaps sharper habitat divisions (Plate III, Fig. A).

I. SEA BEACH

II. DUNES
- A. Live dunes
- B. Grass covered
- C. Wooded

III. SAND FLATS
- A. Interdunal, restricted
- B. Open
  - 1. Dry
  - 2. Moist
    - a. Freshwater
    - b. Brackish to saline

---

*Personal communication from Mr. Verde Watson, Park Naturalist. Mr. Watson wrote that the winter storms of 1955 destroyed more of the barrier dunes than did the summer hurricanes.

IV. TIDAL MARSHES

V. PONDS

I. SEA BEACH

At places the high tide reaches almost to the base of the barrier dunes; in other places, there may be a zone of loose, dry sand several hundred feet wide. Storm tides usually beat against the dunes and cover this zone of loose sand. Exceptionally strong tides have washed out the dunes in places. However, the flood resulting from the onrush of the sound tides caused by these storms usually floods a considerable portion of land from the sound to the barrier dunes and has, at times, broached these dunes. These artificial dunes, formed predominately by sand piled up against the sand fences by the wind, have changed natural conditions so that there is no vegetation between them and the Atlantic Ocean. Thus the normal strand vegetation of Physalis and Croton reported for Ocracoke Island by Kearney (1900) does not exist now. Johnson (1900) reported that Bogue bank had a line of natural dunes above high tide line with no vegetation between the water and the dunes. Beach morning glories, characteristic pioneers of the sand beaches to the southward, are not present from Virginia to Ocracoke Island. The southwestern tip of Hatteras Island has a limited amount of saltmeadow cordgrass as a pioneer on the moist sand beyond the dunes. Two or three species of annual weeds occur there as occasional plants. The sound side of these islands is usually fringed with marshes and the few beaches that exist have some marsh vegetation, along with a quantity of weed species which grow on or between the lines of wave-tossed debris.

II. DUNES

A. Live Dunes.

There are several groups of large, spectacular sand dunes which range from 50 to 70 feet in height. These dunes change their shapes and direction of travel gradually, according to the prevailing winds. The foremost of these is the Kitty Hawk dune from which the Wright brothers launched their airplane. It is now stabilized with plant cover, several hundred feet from its location in 1900. These big dunes are usually without vegetation. The writer found, in a high, quiet pocket among the Seven Sisters dunes at Nags Head, a single plant of saltmeadow cordgrass, Spartina patens, and a single, thrifty plant of sandbur, Cenchrus tribuloides. Their presence here was unusual because of the deep sand beneath them. These large, live dunes are presently invading and killing the forest at Nags Head and in an area just south of Duck.

In addition to the large, live dunes, there are also groups of smaller, low dunes, a few feet high, which also shift around with the winds. However, where vegetation is present, it traps shifting sand and creates new dunes. The sequence of vegetation trapping live sand, death of the vegetation because of the depth it is buried by the sand, the dune moving off after the plants die, is shown by figures 9, 10, 11.

B. Grass-covered dunes.

Most of the artificially constructed barrier dunes are grass-covered, although there are spots where the grass is sparse. Behind the barrier dunes there may be two or three rows of secondary dunes or, as in the area around the Park Headquarters on Bodie Island, a series of discontinuous, individual haycock-shaped dunes (Fig. 12). All these

dunes were formed artificially and originated around sand fences which were constructed between 1936 and 1940. In some places fencing was continuous, in others it was erected to connect individual or clusters of dunes together. This latter technique was used in the vicinity of Avon.

American beachgrass, Ammophila breviligulata (Fig. 13); sea oats, Uniola paniculata (Fig. 14); saltmeadow cordgrass, Spartina patens; and Bermuda grass, Cynodon dactylon, were the principal grasses used for sand stilling in the 1936-1940 reclamation project. The fencing plus the grasses have rendered relatively stable most of these barrier and secondary dunes, except where destroyed by hurricane tides. They generally have developed a good growth of the first three grasses mentioned, and, in addition, have been invaded by certain other grasses, herbs, and occasionally by shrubs. Saltmeadow cordgrass, although widely distributed, grows with more and more spacing between clumps as the depth of the sand increases. It makes its best growth in moist sites. The running beachgrass, Panicum amarum, makes a denser mat than sea oats or the American beachgrass. However its foliage appears to die back in the fall, and it is severely injured by salt spray - more so than the tough foliage of the sea oats and American beachgrass. It has a very good rhizome system and sends up one or two culms at every joint (Fig. 15). These joints have a mass of fine roots. The silver bunchgrass, Panicum amarulum, grows in compact bunches and has a long rhizome system. This species is more abundant on the dunes from Bodie Island northward than on Hatteras Island.

The ability of American beachgrass and sea oats to survive in sand and their role in trapping sand is clearly shown at the southwest end of Cape Hatteras (Fig. 16). Here hurricane "Hazel" cut a dune and left a straight-walled section, 6 to 8 feet high, from top to bottom. At least

three layers of roots of American beachgrass were visible above the bottom, indicating four successive burials and recoveries. There is a general opinion that the value of these plants for sand fixation is that they send their roots down to great depths to secure moisture and thus are able to grow where other plants fail. Actually the growth in most cases is upward and, when buried by a layer of sand, they form new roots close to the surface as well as additional culms. As this new growth progresses, it eventually traps another layer of sand and thus a dune may be formed and partially stabilized.

The following are the most characteristic plants of the ocean beach dunes. Sound side dunes have more woody species and forbs.

Grasses

Ammophila breviligulata	American beachgrass
Cenchrus tribuloides	sandbur
Cynodon dactylon	Bermuda grass
Eragrostis spectabilis	purple lovegrass
Panicum amarum	running beachgrass
Panicum amarulum	silver bunchgrass
Spartina patens	saltmeadow cordgrass
Triplasis purpurea	purple sandgrass
Uniola paniculata	sea oats

Herbs

Croton punctatus	seaside croton
Cyperus sp.	sedges
Heterotheca subaxillaris	camphoree
Juncus sp.	rush
Oenothera lacinata / humifusa	evening primrose
Strophostyles helvola ?	wildbean

Shrubs

Iva imbricata	seashore elder

C. Wooded dunes.

The only appreciable quantity of seaside wooded dunes visited were the little, rolling hummocks near the Cape Hatteras Lighthouse. There is some question as to whether these should be considered dunes or just

mounds in the dry sand flats.

The chief woody species on dunes close to the Atlantic beach are wax myrtle, Myrica cerifera; bayberry, M. pensylvanica; silverling, Baccharis halimifolia; yaupon, Ilex vomitoria; and live oak, Quercus virginiana. These plants are usually dwarfed; the short increments of yearly growth and abnormal branching result in compact, dense crowns. Close to the beach these species may vary from prostrate, trailing plants less than one foot tall to irregular bushes, three to four feet tall (Fig. 17). As the distance from the beach increases, these abnormally-shaped plants get taller (Fig. 18). Typically, they have more branches on the lee side than on the windward side. Many bushes exhibit a crown contour which has a smooth, steep slope from the top of the plant to the ground on the windward side, but on the lee side the slope is quite irregular. These plants look as if they had been sheared and have been called "espaliered-shaped" shrubs in a number of papers.

The sound side dunes are more closely allied to Buxton Woods or remnants of a similar forest. Today either stumps, skeletons, or live oaks occur on the majority of these dunes from Buxton to Oregon Inlet. In places where no trees as such are present, a shrub stage of wax-myrtles, yaupon, silverling, hercules club, and live oak exists, along with many woody vines such as pepper vine, muscadine, fox grape, trumpet creeper, yellow jessamine, and two or three kinds of saw briars.

The area known as Buxton Woods is an example of more or less normal development of woody vegetation on stabilized dunes of considerable age. These dunes consist of a series of parallel ridges alternating with fresh water ponds or saw-grass marshes (Fig. 19). Near Cape Hatteras Lighthouse and the ocean, these dunes are truncated by a large sand flat. Here the

dunes are low and increase in height away from the beach to the vicinity of Frisco where they again flatten out. At the western end of the dunes area, the shrubs and trees are dwarfed and exhibit the espaliered growth form. In contrast, in the central or highest portion of the dunes, the trees are practically normal in shape. At least the live oaks here have tall, straight trunks, although the crowns are somewhat contorted. (Fig. 20).

Loblolly pine and live oak are the major species in this wooded area, although there is a considerable mixture of hardwoods. Most of the pine is of moderate size. Three pines were bored to determine their ages and rate of growth. There were 11, 18, and 20 inches in diameter and their respective ages were 33, 47, and 55 years. They had a rather uniform growth rate of five rings per inch of radius, which is exceptionally rapid when one considers that they are growing on sand dunes.

A fine old live oak, about three feet in diameter, was growing near the base of one of these ridges. It had a straight, clear bole of 16 to 20 feet to the first big knot and about four feet more to the beginning of the crown branches (Fig. 20a). This form indicates that the tree developed under crowded forest conditions and was protected from salt spray injury.

At present part of these woods is being logged and other portions have been logged from time to time in the past. The age and size of the pines indicate one period of cutting. Near the east end of the dunes there is a dense growth of young, mixed hardwood trees with a few scattered, large, unmerchantable individuals. This section was lumbered a short time ago.

The zonation of woody species on these dunes is interesting. The

living live oaks and skeleton trees are in a narrow zone near the base of the dunes, close to the pools between the ridges. The tops of the ridges are covered with loblolly pine and other hardwoods. It is difficult to reconcile the development of live oak and loblolly pine so close together. Live oak is usually considered one of the major climax species of the salt spray climax as defined by B. W. Wells. Thus it would be reasonable to expect that the live oak once covered all the ridges and that the loblolly pine is an invader following the removal of the live oak. Very little pine was in the area studied by Wells (1938). However, records from the early 1900's list loblolly pine on Ocracoke Island, Cape Henry, Va., and the Cape Fear, N. C., areas. At present there is no readily available information on the forest composition on Cape Hatteras in early colonial times.

Eglers' (1942) pine-oak-hickory forests for some of the ridges in the Cape Henry, Va., area seem to describe the relationship existing at Buxton better than Wells' salt spray climax.

A number of hammocks or tree islands are present in the marsh on the sound side of Roanoke Island. These have a fringe of live oak with pine in the center. Thus the distribution pattern of live oaks close to moisture and the pines on the higher, drier positions is so similar to the pine-capped dunes at Buxton Woods as to suggest that this is a natural ecological relationship.

There appears to be a correlation between the trunk height of live oaks with contorted crowns and dune height. If the dunes are low, the trunks are short and the crowns malformed; in the lee of high dunes, the trunks are tall, thus indicating that spray injury does not become serious until the tops of live oaks get close to the dune height (Fig. 20b).

The following plants were observed in Buxton Woods:

Trees, shrubs, and vines

Berchemia scandens	rattanvine
Callicarpa americana	French mulberry
Carpinus caroliniana	blue beech
Cornus florida	flowering dogwood
Gelsemium sempervirens	yellow jasmine
Ilex opaca	holly
Ilex vomitoria	yaupon
Juniperus virginiana	redcedar
Myrica cerifera	common wax-myrtle
Myrica pensylvanica	bayberry, wax-myrtle
Parthenocissus quinquefolia	Virginia creeper
Persea borbonia	red bay
Pinus taeda	loblolly pine
Quercus nigra	water oak
Quercus phellos	willow oak
Quercus virginiana	live oak
Rhus copallina	dwarf sumac
Rhus radicans	poison ivy
Sabal minor	palmetto
Smilax sp.	sawbriar, greenbriar
Vaccinium sp.	huckleberry
Vitis rotundifolia	muscadine
Zanthoxylum clava-herculis	hercules club

Grasses and herbs

Arundinaria tecta	bamboo, switch cane
Asplenium platyneuron	ebony spleenwort
Eupatorium capillifolium	yankeeweed
Mitchella repens	partridge berry
Panicum sp.	panic grass

The woods on Currituck Banks between Nags Head, the sound and south of Kitty Hawk will be referred to herein as Nags Head Woods. This is an interesting area of stabilized sand ridges and valleys containing ponds and moist sites. Floristically, this seems to be a continuation of Currituck Peninsula. One boggy depression has black, mucky soil, carpeted with sphagnum. Ferns are present such as the royal, Osmunda regalis var. spectabilis; cinnamon, Osmunda cinnamomea; southern shield fern, Dryopteris normalis; Virginia chain-fern, Woodwardia virginica; and marsh fern, Dryopteris thelypteris. Along with these is a growth of lizard-tail, Saururus cernuus and water-willow, Decodon verticillatus.

One large shortleaf pine, about 30 inches in diameter, was noticed. If this pine grew at the conventional rate of ten rings per inch of radius, not too fast or too slow, it would be 150 years of age, or a part of the flora which started in the early 1800's. If it grew at a slower rate of fifteen rings per inch of radius, it would have started growth about 1730. These estimates are given to suggest that shortleaf pine was one of the primeval forest trees of this area. Nags Head Woods differ from Buxton Woods in that in general they lack live oak but have beach, Fagus grandifolia; cherrybark oak, Quercus pagoda; and pignut hickory, Carya glabra.

Near the southern end of these woods live sand from the Seven Sisters Dunes is invading the forest. At one location the live dune sand has blown across the woods to the sound (Figs. 21, 22). As the wall of sand advances into the woods, it gradually buries the trees and kills them. The tops of many protrude above the sand. From a short distance these tops appear to be living bushes in the sand. However, closer inspection shows the green foliage belongs to vines such as muscadine, fox-grape, Virginia creeper, peppervine, and trumpet creeper. These vines have completely overrun the dead tree tops and are able to survive burial of 10 to 25 feet because they put out new layers of roots near the surface of the sand, at the same time securing moisture from roots deep in the original soil surface.

There is another wooded area on the sound side, north of Corolla, but it was not visited.

III. SAND FLATS

A considerable acreage of Hatteras Island consists of open, wind-swept sand with a flat to undulating surface. Locally, the term "sand flats" or "flats" is applied to the more or less small, level areas between the dunes. They are restricted or miniature replicas of the large, open sand flats.

Some areas are so dry that there is very little vegetation on them, the chief plants being those which can germinate from seeds during the period of spring rains. Other areas are bare because the winds shift the fine sand around and around, either girdling or burying the seedlings before they can get the sand stabilized. Some areas are bare because the soil water is highly saline. These are interdunal flats which have a marginal fringe of vegetation and a center of packed sand, crusty and frosted with salt crystals. This suggests that these temporary pools or wet spots are too saline for most plants.

One of the extensive, moist sand flats visited is southward from Cape Hatteras Lighthouse. The aerial photographs show many small, almost circular spots. These spots, when examined, were found to consist of small, flat-topped elevations, 50 or more feet in diameter, surrounded by land approximately 18 inches lower. These spots show up in the aerial photographs because of the difference in vegetation. The tops of these elevations have a dense growth of grasses such as the bushy beardgrass, Andropogon glomeratus; purple muhly, Muhlenbergia capillaris; several species of Panicum, and a small quantity of salt-meadow cordgrass, Spartina patens. The herbaceous plants are asters, Aster sp.; seaside goldenrod, Solidago sempervirens var. mexicana; and whitetop sedge, Dichromena colorata. There are usually a few dwarf specimens of live oak, yaupon, and silverling.

The low land around these elevations is poorly drained and, following the hurricane, had from 10 to 12 inches of standing water on it, which was probably abnormally deep. The plants here consisted of the narrow-leaf cat-tail, Typha angustifolia; smooth cordgrass, Spartina alterniflora; black rush, Juncus roemerianus; saw-grass, Cladium

jamaicensis; marsh fleabane, Pluchea sp.; Centella repanda, chair-makers' rush, Scirpus americana; and occasional specimens of saltmeadow cordgrass, Spartina patens. Most of these plants usually grow in more moist sites than those on tops of the mounds.

The distribution of these flat-top, circular mounds is irregular with no definite pattern. However, they resemble the highly dissected, vegetation-capped dunes north of the Park Headquarters on Bodie Island. It is possible to theorize that, because of local drainage conditions, the bases of these sand dunes are saturated, but the tops are dry. The action of the wind planed the dune tops down to a certain moisture level prior to the establishment of vegetation. One of the difficulties with this concept is that most of the dunes are not circular in shape, excepting the dissected dunes on Bodie Island which are more or less circular.

The surface of the sand flat adjacent to these mounds is undulating and, because of poor drainage and low elevation, the depressions are more moist than the raised areas. Here the vegetation produces a pattern of black rush and chair-makers' rush in the depressions alternating with bushy beardgrass and purple muhly on the crests.

Closer to the barrier dunes, the surface flattens out with a slight lowering of the slope inland from the coast. This is an area which has been selected for future camp sites. Much of the area was under water following hurricane Hazel in 1954. The prevailing plants on the site, the surface of which varied from moist to water two inches deep, were saltmeadow cordgrass and sea oxeye. The portion that was covered by water three to four inches in depth had a dense growth of black rush.

Figures 23, 24, 25 show characteristic conditions of the dry sand flats. This variation in degree of cover occurs from place to place. In an area

south of Avon, between the highway and the sound, the land is low and moist at times, and has been invaded by marsh elder and silverling.

Plants observed on the sand flats:

Trees, shrubs, and woody vines

Ampelopsis arborea	pepper vine
Baccharis halimifolia	silverling
Borrichia frutescens	sea-oxeye
Hypericum sp.	St. John's wort
Ilex glabra	gallberry
Ilex vomitoria	yaupon
Iva frutescens	marsh elder
Myrica cerifera	common wax-myrtle
Myrica pensylvanica	bayberry
Persea borbonia	red bay
Prunus sp.	plum (planted ?)
Quercus virginiana	live oak
Rhus copallina	dwarf sumac
Salix nigra	black willow
Smilax sp.	green briar or saw briar
Pinus palustris	longleaf pine (planted)
Pinus taeda	loblolly pine (planted)

Grasses

Andropogon glomeratus	bushy beardgrass
Andropogon virginicus	slender broomsedge
Ammophila breviligulata	American beachgrass
Chloris petraea	windmill-grass
Cenchrus tribuloides	sandbur
Distichlis spicata ?	seashore saltgrass
Digitaria sanguinalis	crab grass
Echinochloa walteri	Walter's barnyard grass
Elymus virginicus var. halophilus	glaucous wild-rye
Erianthus giganteus	sugarcane plume-grass
Muhlenbergia capillaris	purple muhly
Panicum sp.	panic grasses
Panicum scoparium	
Panicum virgatum	switch grass
Paspalum ciliatifolium	
Paspalum vaginatum	knotgrass
Setaria geniculata	foxtail grass
Spartina patens	saltmeadow cordgrass
Sporobolus poiretii	smut grass
Triplasis purpurea	purple sandgrass

Herbs

Ambrosia artemisiifolia	lesser ragweed
Anaphalis margaritacea	pearly everlasting
Apocynum sp.	dogbane

Herbs (cont.)

Aster spp.	asters
Bidens sp.	sticktights
Centella repanda	
Cassia fasciculata	partridge pea
Castalia / Nymphaea	water lily
Cirsium horridulum	spiny thistle
Cladium jamaicensis	saw-grass
Commelina sp.	
Croton punctatus	seaside croton
Cyperus spp.	sedges
Diodia teres	poorjoe
Diodia virginiana	buttonweed
Erigeron canadense	horseweed
Eupatorium sp.	
Eupatorium capillifolium	yankeeweed
Euphorbia polygonifolia	creeping spurge
Euthamia caroliniana	flattop goldenrod
Fimbristylis castanea	sandrush
Gaillardia puchella var. picta	blanket flower
Galactea volubilis	milk pea
Gerardia sp.	fox glove
Heterotheca subaxillaris	camphor weed
Hydrocotyle umbellata	pennywort
Lechea villosa	pinweed
Lippia nodiflora	frogbit
Oldenlandia uniflora	
Opuntia drummondii	cactus
Mikania scandens	climbing boneset
Persicaria sp.	smartweed
Physalis viscosa	ground cherry
Phytolacca americana	poke weed
Pluchea spp.	marsh fleabane
Polypremum procumbens	
Rubus sp.	blackberry
Rubus trivialis	dewberry
Scirpus americana	chair-makers' rush
Solidago sempervirens var. mexicana	seaside goldenrod
Typha angustifolia	narrowleaf cat-tail
Typha latifolia	cat-tail

IV. TIDAL MARSHES

The western side of the Outer Banks from Virginia to Ocracoke Island is fringed with a brackish to saline vegetation. These marshes are very extensive and heterogenous. One of the outstanding features is the micro-zonation exhibited in them. Differences in composition of the substratum and elevation influence drainage, soil saturation-aeriation ratios, and flooding

by tides. The bulk of the marshes visited are very different from Louisiana marshes with the same species composition in that these marshes are on hard, packed sand. One can walk out on them without sinking and, at low tide, without even getting one's feet wet. In a few places there is an organic, peaty substratum which is soft; such as the marsh back of the pine plantation south of Salvo and the one in the Salvo village area. Three islands in Roanoke sound, south of the causeway from Whalebone Junction to Manteo, namely Green, House and Headquarters Islands, have a definite, compact, clay substratum. Similar habitats in Louisiana would be wet under foot and there would always be danger of breaking through the rootmat and sinking knee, waist, or armpit deep in muck. (Figs. B, C, D, E, F, Plate III).

The smooth cordgrass, Spartina alterniflora, grows out into the saline sound waters to a depth of about ten inches and extends shoreward to an elevation of about a foot above the sound, but within the area normally flooded by normal sound tides. Back of the smooth cordgrass is a zone of saltmeadow cordgrass which, at first, is mixed with the smooth cordgrass on the low side, and as the elevation of the ground increases, becomes an expanse of pure saltmeadow cordgrass. If this zone is narrow, it contains a quantity of sea-oxeye, Borrichia frutescens, which predominates at times. Next to the saltmeadow cordgrass and a little higher, is the black rush zone. The aggregate area of this species is in the hundreds of acres in which it forms 95 per cent of the ground cover. As the elevation of the substratum increases, the black rush is invaded by a variety of plants. Often there is a narrow zone of the big cordgrass which is invaded by marsh elder, silverling, sea-oxeye, hibiscus, Kosteletzkya and sandrush.

On sand substrata apparently the more usual zonation is from black rush to shrub zone and then to the sand flats. Thus shrub zone is found along the contour of the debris drift associated with storm tides, but not hurricane tides as these sweep over the sand flats and break on the barrier dunes.

On some places on the hard, packed sand a zone of knotgrass, Paspalum vaginatum, occurs between the smooth cordgrass and the saltmeadow cordgrass. A slightly different type of zonation was observed along the sound between Buxton Woods and Frisco. Here the slope was more gradual and there were four lines of vegetable debris, chiefly eelgrass. The zone of smooth cordgrass was followed by the American chair-makers' rush which grew in water about four inches deep to about two inches above low tide. The next zone was of knot grass containing a few plants of waterhemp, sea-purslane, carpetweed, and barnyard grass. These, along with sea-rocket, were more abundant on the second line of drift above the sound. Then came the saltmeadow cordgrass, followed by the wooded dunes. These relationships have been diagrammed on figure B, Plate No. III.

Although three species of saltworts were seen, they were nowhere abundant enough to have any ecological significance.

Plants observed in or adjacent to the salt marsh:

Woody

Baccharis halimifolia	silverling
Borrichia frutescens	sea-oxeye
Iva frutescens	marsh elder
*Myrica cerifera	common wax-myrtle
*Myrica pensylvanica	bayberry

Grasses and herbs

*Andropogon glomeratus	bushy beardgrass
Aster maritima ?	aster
*Dichromena colorata	whitetop sedge
Distichlis spicata ?	saltmarsh grass
*Eragrostis sp.	

Grasses and herbs (Cont.)

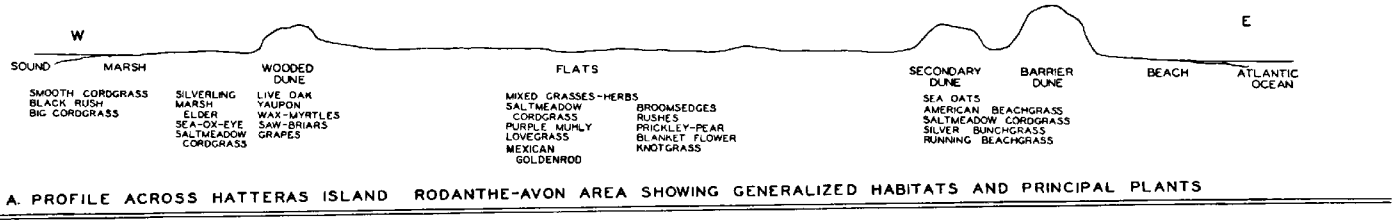
*Fimbristylis castanea	sandrush
*Galactia volubilis	milkpea
Juncus roemerianus	black rush
*Paspalum vaginatum	knotgrass
Salicornia herbacea	glasswort
Scirpus americana	chair-makers' rush
*Setaria sp.	foxtail
Solidago sempervirens var. mexicana	seaside goldenrod
Spartina alterniflora	smooth cordgrass
Spartina cynosuroides	bigcord grass
Spartina patens	saltmeadow cordgrass

The plants marked with an asterisk are not properly true marsh plants. They are included here as plants which are adjacent to the marsh proper and occupy a transitional area between the marsh and the sand flats.

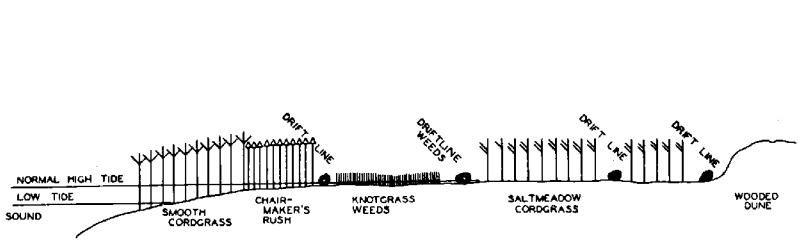
V. PONDS

Several large, freshwater ponds occur between the truncated dunes near Cape Hatteras Lighthouse. They have a fringe of fresh water plants such as cat-tails, Typha latifolia and T. angustifolia; chair-makers' rush, Scirpus americana; stick-tights, Bidens sp.; Centella repanda; pennywort, Hydrocotyle sp.; saw-grass, Cladium jamaicensis; smartweed, Persicaria sp.; and black willow, Salix nigra. The foliage of a true water lily, Castalia or Nymphaea, was seen in one of the ponds. These ponds are remnants of larger pools which once occupied all of the valleys in the region between Buxton and Frisco. A comparison of old maps and recent aerial photographs shows the changes in the shape and size of the ponds. (Plates IV and figures 30, 31, 32).

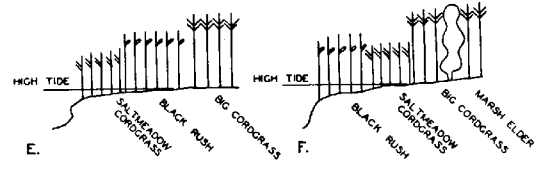
Saw-grass and cat-tails are the prevailing plants in the one-time pond between these sand ridges. At the western end, several small islands in the saw-grass marsh once had a growth of live oak on them.



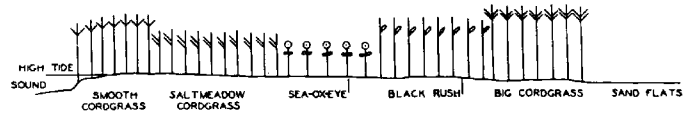
A. PROFILE ACROSS HATTERAS ISLAND RODANTHE-AVON AREA SHOWING GENERALIZED HABITATS AND PRINCIPAL PLANTS

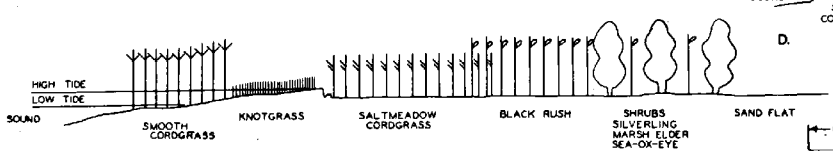


B. SAND SUBSTRATUM-WEST OF BUXTON

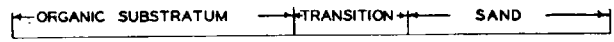


CLAY SUBSTRATUM ISLANDS IN SOUND





C. SAND SUBSTRATUM-RODANTHE-AVON



TYPES OF VEGETATION ZONATION OBSERVED ON HATTERAS ISLAND

Plate III

The skeletons of these trees are still standing today (Fig. 19). The cause of their death is not known but fire has killed much of the pine and hardwood growth on the adjacent ridges. C. T. Iardella did not survey this area of saw-grass marshes, ponds, and wooded ridges in 1872. He wrote on his map "This pond leads into Cape Hatteras ponds; it was impossible for me to get through as this unsurveyed portion is nothing but swamp and thick woods."(U. S. Coast Survey 1872, Reg. No. 1246).

There is a large, fresh water pond at Bodie Island Lighthouse which diminishes in size from spring to fall. The margin of this pond has many interesting plants. The dam on the outlet stream is about all that keeps this pond in existence. It is being filled gradually by the invasion of vegetation capable of withstanding permanent water and by invasion of wind-blown sand. The high organic content here has produced a soft, mucky edge to the pond, a rarity on the Outer Banks.

About one and a half to two miles north of Bodie Island Lighthouse and a half mile west of the main highway is a large, oval basin, a semi-permanent pond, and a smaller, oval pond (Fig. 26). Both of these contain several small mounds. They are shown on aerial photos Nos. 506, 507, and 508 of 1952. The high mounds have both species of Myrica, Iva frutescens, Baccharis halimifolia, Andropogon virginicus, Spartina patens, and Uniola paniculata. The bottom of the basin is uneven and is partly carpeted with Spartina patens, S. alterniflora, Typha angustifolia, Cyperus sp., and, along the margins, Spartina cynosuroides. The water was three to five inches deep over a large portion of the area covered by Spartina patens. A muskrat house was seen here. It is apparently a favorite duck hunting locality as several duck blinds had been built by hunters. The land on the western side of the basin rises up to the

sound side dunes which have a good cover of woody plants. Some of the land adjacent to the basin is wet, black, and mucky -- almost impassable to a jeep - and has a strong hydrogen sulphide odor. One of the outstanding features is the presence of several sound redcedar stumps, four to six inches in diameter, and standing in water to a depth of two to four inches. It is impossible for redcedar to grow here today under present conditions. Thus, at the time these trees started growth, the ground must have been moderately well drained. These trees indicate that a maritime forest was present on Bodie Island sometime in the past. It seems possible that drifting sand may have blocked or altered drainage and caused the development of this pond area. Man has trenched three sides of the smaller pond and one side of the larger basin in an attempt to improve drainage.

Several ponds, in all stages, from open water to grass-and tree-filled, are found in the Nags Head Woods. One of these intermittent ponds or sinkholes has a moderate stand of red maple and red gum. There was no ground floor vegetation because it had been covered with standing water until August and this, coupled with dense shade, prevented any invasion by the summer plants at that late date.

GEOGRAPHIC LOCATIONS

OCRACOKE ISLAND

Ocracoke Island is about 17 miles long and has an average width of close to one-half mile. The widest portion is at the southern end and is about two miles wide. The bulk of the island consists of barren beach (composed of sand and ground sea shells); sand flats known as Tarhole Plains, the Great Swash, and The Plains; and large dunes such as Styron Hills, Quarks Hammock, Knoll Oaks, Knolls Cedars, Scrag Cedars, the Six-mile Hammock, and the "Island." The highest elevation is about 26 feet. A large

portion of The Plains and Tarhole Plains is covered with sea water to a depth of four to six inches with normal high tides and completely awash during storm tides. They are completely without vegetation. The Great Swash is now carpeted with plants characteristic of the sand flats of the remainder of Outer Banks. Styron Hills is now covered with typical dune grasses, sea oats, American beachgrass, and saltmeadow cordgrass. The remainder of the big dunes have an arborescent vegetation consisting chiefly of yaupon, both wax-myrtles, hercules club, redcedar, and live oak. Some of these exhibit the picturesque, knarled, dwarfed growth which results from salt spray. The live oak and redcedar once were tree-like on certain areas. The largest redcedars seen are now dead but still standing. The sound side of Ocracoke Island is fringed with a salt marsh and has such characteristic plants as smooth cordgrass, saltmeadow cordgrass, black rush, salt grass, marsh elder, and silverling.

The vegetation of Ocracoke Island is essentially the same as that on Hatteras and Bodie Islands. A few additional items can be mentioned. The storm of 1933 naturally flooded a considerable portion of the area and dropped quantities of salt spray which was not washed off, as little rain accompanied this storm. Thus, large, old redcedars in the "stock-pen area" were killed. Many other kinds of plants were also injured or killed at the same time. There are live oak thickets in this area which consist of saplings two or three inches in diameter with whitened tops. These saplings are bent and contorted by the salt spray which apparently comes with sufficient regularity to produce this deformity.

Very little sand fencing was used on Ocracoke Island and these fences appear to have been less effective in building barrier dunes than on Hatteras, Pea, and Bodie Islands.

ROANOKE ISLAND

Roanoke Island is located between Bodie Island and the mainland, with the wide expanse of Croatan Sound on the western side and Roanoke Sound on the eastern side. Nearly all of the eastern, southern, and western sides of this island are fringed with a black rush marsh covering hundreds of acres. Here and there the marsh is dotted with "islands" or hammocks on which pines and live oaks grow. These will be discussed in more detail later.

Although much of the better land of Roanoke Island has been settled and cultivated for many years, it is still possible to recognize several major plant communities. The northern portion of the island is deep sand, and, in the vicinity of Fort Raleigh, the surface of the sand is more than 20 feet above sound level. It consists of low, rolling sand hills. The tree vegetation here is different from that of other portions of the island and consists of a dense covering of shortleaf pine, loblolly pine, redcedar, live oak, laurel oak, willow oak, blackjack oak, bluejack oak, southern red oak, persimmon, red bay, fringe tree, redgum, sassafras, holly, flowering dogwood, blackgum, and several kinds of huckleberries or relatives. One is impressed with the quantity of partridge berry in the shade under these trees.

Just south of Manteo along the road to Wanchese, the vegetation changes. This flat area is poorly drained. The marsh or pond pine, Pinus serotina, is present here in addition to shortleaf and loblolly pines. This area has been lumbered, thus the stand of timber is not as dense as in the vicinity of Fort Raleigh. Some of the additional tree species are baldcypress (pondcypress phase), live oak, blackjack oak, sweet bay, redbay, dwarf sumac, hackberry, sassafras, swamp blackgum, red maple, and blackgum. The outstanding feature here is the moderately dense growth of grasses and the variety of herbs and small shrubs. Some of these are yellow polygala, orange

polygala, white-fringe orchis, white sabatia, bracken, Virginia chain-fern, dwarf huckleberries, chokeberry, saw-grass, broomsedge, two or three kinds of saw briars, gallberry, and yellow-eye grass. The term "pocosin" is applied to this type of community on the mainland.

The marshes nearly pinch Roanoke Island into two portions between Manteo and Wanchese. About two miles south of Manteo the marsh from Roanoke Sound is close to the highway. Although black rush is the prevailing plant for hundreds of acres, minor amounts of saw-grass, saltmeadow cordgrass, sedges and Centella are intermixed with it. The black rush marsh is firm and growing over a compact, sand foundation. Here and there in the marsh are pine-oak hammocks; slight mound-shaped elevations with an interesting zonation of vegetation. As the ground starts to rise from the black rush marsh proper, the saltmeadow cord-grass, saw-grass, and sawbriars become more abundant. There is an indistinct zone of switch grass and foxtail grass. This is followed by the shrub zone in which silverling, marsh elder, wax-myrtle, live oak saplings, gallberry, bamboo, redbay. blackberries, poison ivy, broom sedge, eupatoriums, and saltmeadow cordgrass have invaded the black rush. The central and highest portion, only two or three feet above the marsh proper, has a tree zone with pond pine, shortleaf pine, redgum, and sweet bay as the prevailing trees.

The understory to these trees consists of gallberry, a wild rose, dwarf sumac, bracken, marsh-mallow, and red asclepias, laced together with sawbriars, and muscadine vines.

A little farther south the highway skirts the marsh on the west. One of the outstanding items here is that cypress trees, nearly all dead, fringe the black rush.

Near Wanchese the following zonations were observed. The higher ground contains pine and oak, and has a shrub margin of wax-myrtle, silverling, and marshelder. Big cordgrass predominates in the next zone and is followed by a mixed marsh of saltmeadow cordgrass. Finally there is an extensive zone of black rush. Debris zones or wave-tossed levees fringe the black rush and may have big cordgrass and saltmeadow cordgrass on them. One depression along the road was carpeted with Distichlis spicata, and surrounded by saltmeadow cordgrass.

CURRITUCK PENINSULA

The road from the Virginia State line (Hwys. 34, 158) down the Currituck Peninsula passes through a rich farming land. The trees now remaining there are pines; a variety of hardwoods on the high ground; and cypress, swamp blackgum, and red maples along the streams and low places. Beech, one of the common trees, was conspicuous in April, 1955, because it was flowering. A number of side trips were made to visit the western side of Currituck sound. One trip was along the road to Bells Isle. About a mile from the main road, the land drops abruptly to the sound. Pine, oaks, black walnut, and tulip trees are growing just above the escarpment, which is less than 10 feet high. Immediately at the base of the escarpment pine and sweet gum are growing which, as the drainage becomes poorer, are replaced by cypress and swamp blackgum. These are succeeded by wax-myrtle, and finally by the marsh. The marsh vegetation consists of big cordgrass, switchgrass, arrowhead, pickerel weed, both species of cat-tails and the black rush. Scattered throughout the marsh are plants of climbing boneset, silverling, marsh fern, royal fern, Virginia chain-fern, and red-flowered milkweed. Along the higher road shoulders such plants as black cherry, sweet bay and persimmon occur. Widgeon grass is abundant in the roadside canals. This same marsh fringe,

with minor differences in secondary components was observed at two other locations.

Plants such as switchgrass, arrowhead, pickerel weed, royal fern, and Virginia chain-fern suggest a fresh water habitat. However, in crossing the sound from Poplar Branch to Corolla, the water in the sound had a slight but definitely brackish taste although the local inhabitants state the water is usually fresh. Thus the minor components in the marsh fringe must be fresh-water plants which can tolerate a slight amount of salt and grow in a brackish habitat.

CURRITUCK BANKS

This name is applied to the area which extends from the Virginia-North Carolina state line south to Nags Head, a distance of about 25 miles. This segment of the Outer Banks is also known as the North Banks and consisted in the past of several islands divided by inlets such as Currituck Inlet, Caffee Inlet, and Nags Head Inlet. These inlets have all been closed by shifting sands.

At one time the entire Currituck Banks was within the proposed boundaries of the National Seashore Recreation Area and was included in the sand fencing and planting projects prior to 1936. Later this area was excluded from the present park boundaries.

Description of the Currituck Banks will be general as it was visited only twice. It is of considerable interest, however, because the sand fencing and planting has been partially continued either by state agencies or by private individuals.

The original sand fencing created a more or less continuous barrier dune which has been planted with sand binding grasses. This stabilization

reduced the sand shifting on the flats and allowed considerable native vegetation to develop. Prior to the establishment of the sand fences, the condition of the Currituck Banks was very much like that of Hatteras Island. The area from Duck northward to the state line consisted of a wide sea beach, sand flats, a number of live dunes and, adjacent to the marsh on Currituck Sound, a discontinuous line of smaller dunes, more or less wooded.

The area from Duck southward to Kitty Hawk has many small dunes adjacent to the ocean shore while inland are larger dunes, some of which are wooded. These wooded dunes form a series of ridges on Jean Creek with well-developed marsh areas between them. This is best seen at the eastern end of the Wright Memorial bridge which joins Currituck Peninsula with Currituck Banks. The road crosses the marsh of the above mentioned stream which flows between two wooded ridges. Since the 1930's, live dunes have been invading and killing the woods.

Northward from Duck to the vicinity of Caffee Inlet Coast Guard Station, the road follows along the sound side of the banks. Glaucous wild-rye grass is abundant in this area. The road from Caffee Inlet Coast Guard Station northward passes through the interior of the island for several miles before it comes out onto the Atlantic beach. The vegetation here is mostly grasses and herbs with a quantity of low shrubs and trees. In other words, the sand flats are in the process of being invaded by an arborescent vegetation. It is remarkable to see the density of plant growth now covering former Caffee Inlet. This has developed since the closing about 1800.

Conditions northward to the state line are similar to those on Bodie and Hatteras Islands in that a wave-washed beach, barren of vegetation, fronts the barrier dune which was formed by sand fencing. This dune is covered with sea oats, American beachgrass, silver bunchgrass, and saltmeadow

cordgrass. Inland from the barrier dune are level or slightly undulating sand flats; followed by the discontinuous, low, soundside dunes covered with an arborescent vegetation; and finally fresh to brackish marshes.

There are four outstanding features in the above area. First are the eight or nine large dunes with a maximum elevation of about 65 feet, similar to the group known as Seven Sisters at Nags Head.

Second is the area known as Wash Woods which consists of three clumps of stumps in place along the outer edge of the beach between low and normal high tides. (Figs. 2, 3). The exposed stumps can be found along the beach for a distance of two or three miles. Each stump was examined and the wood identified. Redcedar and live oak are the prevailing species. One stump of cypress and three or four of mulberry were found. The following historical account by Henry B. Ansell(1903-12) appears to refer to these stumps:

> Before this storm (of March, 1846) the beach opposite the island (Knotts Island) consisted of high sand-hills and ridges. The height of these ridges greatly increased since the war of 1812.....This storm tide has cut these ridges away and in their stead, at a certain point on the beach, appeared.....a large thicket of dead cedars, whose gigantic arms stretched impressively heavenward. Uncle Jimmie Beasley knew all about these cedars, for he had boiled salt water under the trees in the war of 1812; their thick foliage had screened him and others from the view of the British as they passed up and down the coast.
>
> He said he had left his salt pans there; they had been sanded up and the cedars with them; now he could get them. He got some help and went over, the writer and his father along with them.....Two of the pans three feet by six feet and ten inches deep, were found a little below the surface. He carried them home after they had been buried over thirty years.
>
> These cedars were dug up by ... the industrious ones, prepared for vessel timbers, and sold to B. T. Simmons and Wallace Bray for that purpose.

The Wash Woods area is north of Corolla and opposite Knott Island. Certainly these trees are a testimony to the rapidity of physiographic

changes. If one considers that they were once behind a dune, then some quantity of sand was blown on them and then blown away. The fact that roots of these stumps are exposed close to the low tide level suggests that either there was a considerable distance between them and the ocean when they started to grow or that there has been a marked change in elevation of the land or sea. Certainly it would be difficult to establish these species today in a habitat that has the same relative lowness.

The third noteworthy item is that the North Carolina Highway Commission, in the fall of 1952, erected a mile or so of snow fence in one stretch and two or three smaller segments. (Figs. 27, 28). In back of the longest segment they set a second fence in a zigzag line. At places where the two fences are from 25 to 35 feet apart this fencing trapped a solid wall of sand at least 100 feet wide at the base and from 30 to 40 feet wide at the top. Where the two fences are about 100 feet apart there is a trough between the two lines of smaller sand ridges which parallel the fence. It is obvious that two lines of snow fencing, about 25 to 35 feet apart, is a better form of construction in that it trapped enough sand to form a solid low dune about four feet high. This was accomplished in a short space of three years. If some vegetation could be planted, this would soon become a fixed dune.

The fourth important item concerns the activities of a private individual in sand fixation. Mr. Ray T. Adams of Washington, D. C., in 1938 purchased the old Whalehead Clubhouse and some 3000 acres of land. He furnished the following information concerning his property which has some five and a half miles of beach frontage. When he acquired the land it was essentially a barren sand flat from the ocean nearly to the sound. The land had an average elevation of four feet above high tide. Today it has an elevation of more than twelve feet. He has planted some 850,000 seedlings during the

past twelve years. These seedlings include some 16 kinds of pine with an overall survival of 80%. He has sown a variety of grasses but did not know what kinds or quantities. Mr. Adams kindly furnished the aerial photo for Figure 29, which was made about the time he acquired the property. This shows the barrier dune developing on the sand fence established by Stratton and Hollowell in 1936. It also shows that a considerable area back of the barrier dune was planted to grass. Beyond this area there is a large, irregular plot of bare sand, followed by a darker toned zone consisting of grass, shrubs, and trees adjacent to the marsh. A large part of this bare sand area now has on it small trees and shrubs. (Fig. 29). Although Mr. Adams reported planting only coniferous seedlings, there are numerous small live oaks and wax myrtles growing in this area.

This year to year planting by an individual has definitely shown that it is possible to revegetate the sand flats. The best growth, and perhaps the oldest trees are farthest from the Atlantic beach. This may be accidental because the first plantations were in this area, or it may be related to the distance salt spray is normally carried.

The pines and redcedar in the plantation on the sand flats did not show any salt spray injury on the first visit in August. They did show considerable injury in October, 1955, after three hurricanes. Here, as elsewhere on Bodie and Hatteras Islands, the maritime pine, Pinus pinaster, did not show any browning of the needles such as occurs on the native pines. The terminal buds and leaders of the trees between 10 and 15 feet tall did show injury. The buds seemed to open prematurely, giving rise to abnormal branching. Many of the needles on the terminal leaders had been shed.

A more detailed survey of this area may reveal information as to why these plantings showed less spray injury than those at Avon. Perhaps such factors as wind direction, distance of salt spray travel, and proximity to the beach should determine in part the location of future plantations on the Outer Banks.

A CENTURY OF CHANGE AT CAPE HATTERAS

Rapid changes in the physiography and vegetation of the Cape Hatteras area have taken place. These can best be seen by comparing maps dated 1852, 1872, (Plate IV) and aerial photographs made between 1936-40, 1946 (?), and 1952 (Figs. 30, 31, 32). These maps and photographs cover the changes of a century. The 1852 map, made to the scale of 1/20,000, shows many details of the physiography in the cape area. Foremost is a zone of sand flats and sea beach about 3,500 feet wide, between the lighthouse and the Atlantic Ocean. A small pond is located at the extreme end of the cape and it is connected to the Atlantic. Two ponds near the lighthouse have a general east-west alignment and a smaller one extends north-south. This latter pond drains into a marsh area north and east of the present village of Buxton. A small sand dune with two high spots is located directly east of the north-south pond. The symbol for marshes is used on the sound side north of Buxton. Most of the interior portion is marked with a symbol which is interpreted to mean woods vegetation.

There is only one positive identification of plants in this area on the maps. The survey station is labeled "Palmetto" and, in view of the fact that palmettos grow there today, it seems reasonable to believe that this name was based upon the presence of this plant. Today, large live oaks of sufficient size occur in the areas marked "wooded" on the map to suggest that they are remnants of the original forest. These, together with the present flora and the vegetation recorded in previous studies on the Outer Banks, suggest a maritime forest in 1852 which was very similar to that found in Buxton Woods today (see Page 30). Some of the ponds, as the shape and alignment indicates, were between parallel

CHANGES IN VEGETATION
AND PHYSIOGRAPHY IN THE
CAPE HATTERAS AREA
WOODED
MARSH
TOWNSITE
WATER
SAND
0
MILES
NEW LIGHTHOUSE
OLD LIGHTHOUSE
35° 14'
75° 31'
U.S. COAST SURVEY
REGISTER NO. 1248
1872
1852 SHORELINE
LIGHTHOUSE
Pond
Palmetto
Buxton
35° 14'
75° 31'
U.S. COAST SURVEY
REGISTER NO. 377
1852

Plate IV

ridges, such as is the case today. There is nothing to indicate whether they were open or the extent of filling. The area designated as marshes was probably much the same then as it is now.

The 1872 map (Plate IV) locates the old lighthouse and a new one which was built in 1870 and is still in use. There is less detail on this map than on its predecessor. The most important item is that it shows considerable loss of beach, about 1800 feet in 20 years. This map shows the 1852 shoreline as a dashed line, thus allowing a direct comparison of the extent of beach erosion. The north-south pond is 10 to 14 times larger than in 1852. The 1872 maps shows it connected directly with one of the east-west ponds. The extreme tip of the cape has changed and the pond of 1852 is almost obliterated, but there is a new pond some 1600 feet northward of it. Fronting the sand beach and sand flats on the south side is a zone of regularily placed dots which were apparently intended to designate some vegetation. The interior part, westward from the portion herein reproduced, bears this comment "This pond leads into Cape Hatteras ponds: it was impossible for me to get through, as the unsurveyed portion is nothing but swamps and thick woods." Signed C. T. Iradella.

The first of the aerial photographs covering the Cape Hatteras Lighthouse area, No. 01803, was made between 1936 and 1940. The exact date was not obtainable. (Fig. 30). Certain specific items of interest have been marked with letters and arrows so that the same places can be located on figures 30, 31, and 32. The location of sand fences is indicated by "A". Three distinct fence lines appear in the northeast corner of figure 30 and one in the southeast corner. The Civilian Conservation Corps' camp, which was removed upon completion of the work in 1940, is marked by letter "B". The location of the lighthouse is shown

by letter "C". The beach at the base of the lighthouse is about 300 feet wide. The large, nearly bare sand is undulating and is highest at the contact with the sand ridge just under the letter "D". The scant vegetation apparently consisted of herbaceous vegetation and a few shrubs. The letter "E" is placed over one of the east-west ponds shown on the 1852 map. It is now largely a saw-grass marsh. There are a few open water spots, one of which is indicated by the letter "F". The trails "G" parallel the marshes at the bases of the sand ridges. The black, narrow streak "H" is interpreted as a pond between two rows of sand fencing. The letter "I" locates a north-south pond which apparently was present in 1852 and 1872. This pond drains northward to the sound. The lighthouse "C" was abandoned about 1935. However the sand fences "A" helped to form dunes, erosion was arrested and as a result, the beach was extended seaward so that the threat of undermining the lighthouse was mitigated. The light was then placed back in service in 1950.

The aerial photograph, No. 15, 878, was made about 1946 (?) (Fig. 31). It shows considerable change in the vegetation as compared to figure 30. Comparative areas carry the same letter designation. Compare the bare area "D" of figure 30 with the same area on figure 31. The change in a period of about 12 years is very interesting. It was not possible to find out how much planting was done in this area. Maritime pine, an introduced tree, is present and reseeding naturally. A fire has burned through part of this area and killed most of the larger specimens of the maritime pine. It is obvious that sand fencing and plantings have reduced the shifting of sand, thus allowing native vegetation to get a start in it. This vegetation consists of a mixture of herbaceous and woody species which were not planted. This aerial photograph shows about 60% more vegetation than in Figure 30. "E" is the

sawgrass marsh between the wooded ridges. The pond "F" is much larger than in the preceding illustration. The trails "G" are not as distinct, presumably the result of shrubs and trees encroaching on the margins of the trails. The ponds "H" and "I" of figure 30 no longer exist.

The Outer Banks were covered by an aerial survey again in 1952 and Photograph No. 349 (Fig. 32) covers most of the area shown in figures 30 and 31. The fence line "A" is now a barrier dune with a dense grass vegetation on each side of the crest. The foundations of the Civilian Conservation Corps building "B" are still visible. "C" marks the location of the lighthouse. The open area to the southwest of the lighthouse "D" is better than 85 per cent covered with herbaceous vegetation, trees, and shrubs. The saw-grass march "E" is better delimited on this photograph because of the better contrast. Likewise, pond "F" is more distinct, with its irregular margin showing the same pattern as in figure 31. The vegetation of the area between the sand fences "A" in the northeast corner is illustrated by figure 36 which was taken from the top of the lighthouse. This was bare sand in 1936.

The area around Cape Hatteras Lighthouse was studied with the aerial photographs in the field in order to interpret certain items observed on the print. The irregular light-colored areas with tiny, darker dots represent raised sand mounds which are nearly bare. The dots represent small, dwarfed and often prostrate specimens of live oak, yaupon, and wax-myrtles. The mounds are bordered with irregular, dark lines which were found to represent depressions which had dense stands of Cornus sp., marsh-elder, silverling, and a variety of grasses and herbs (Fig. 35). The uniform gray areas represent sand covered with grasses. The northern half of the aerial photograph, not reproduced

here, shows more clearly than the others a series of parallel ridges with intervening ponds, or saw-grass -- cat-tail marshes of former ponds.

The vegetation of the ridges is a mixture of pine-hardwoods, with the pine representing a secondary growth about 50 years of age. The vegetation on the eastern end of these ridges is dwarfed, salt-wind-shaped live oaks and yaupon but farther inland the live oaks and other trees have normal boles. (See section on Buxton Woods, page 30).

These two maps and three aerial photographs cover a span of one hundred years. They tell a story of changes in the physiography and vegetation of the area. One of the important items that is noticeable on the photographs is the rapidity with which vegetation invaded the bare sand as the result of construction of sand fencing and the planting program.

A similar story can be obtained from comparisons of pictures of the three aerial surveys for other locations on the Outer Banks. Pictures of the first aerial survey, made between 1936 and 1940, show the location of the fencing erected and the fence type as long, straight lines, or saw-toothed and scalloped arrangements. Certain areas have only a single line of fence; others have two or three rows of fences, along with cross and branching fences.

Aerial photographs give a better idea of the general physical condition of the Outer Banks and the location of the vegetation than do most of the fragmentary comments in the literature. They show, in the vicinity of Avon which is reasonably typical for most of Bodie, Pea, and Hatteras Islands, a long, low, barren sand flat extending from the Atlantic Ocean almost to the sound-side dunes or to the edge of the marsh. Mile after mile of this was a barren waste, broken here and there by clusters of small, irregular, low dunes which were partly capped with plants. Much of this area must have

been covered with storm tides before the sand fencing program. The dunes on the sound side usually fringe the marsh and are quite dark on the aerial photographs, which suggests a dense vegetation cover. The present studies show that such dunes are covered with a variety of herbaceous plants, dwarf shrubs, and an occasional large live oak. The marsh section shows a mosaic of light and dark areas. However, the dark areas of the marsh are lighter in color than the wooded dunes.

SALT SPRAY INJURY

The breaking or cresting of waves expells tiny droplets of sea water into the air. Breezes carry these droplets varying distances, depending upon their size and the wind velocity. Large droplets fall before small ones and, as wind velocity increases, a given sized droplet is carried farther. It has been determined experimentally that a water droplet one-tenth of a millimeter in diameter will travel nearly thirty feet in a four-mile wind when released five feet above ground, and a droplet one one-hundredth of a millimeter in diameter will travel nearly 3,000 feet under the same conditions. Storm and hurricane winds carry the salt spray much farther. The fallout of the larger droplets has a marked effect upon vegetation. Thus the volume of salt and distance of dispersal under normal wind velocity is quite different as compared to winds of storm or hurricane strength. Although trees have died from the effects of salt toxicity following hurricanes, it is the day by day deposition of salt spray a short distance from the beach which influences the strand vegetation and is responsible for the zonation usually found.

Moss (1940) reported on damage done in New England by the hurricane of September 21, 1938. The wind stripped the leaves from deciduous trees. There was one hundred per cent foliage injury on trees in a zone from five to ten miles wide along the coast. Salt injury to sensitive plants was detected 45 miles from the coast when the wind velocity was over 100 miles per hour. Moss observed the following plants were either resistant or moderately so to salt toxicity: Colorado blue spruce, Picea pungens var.; yew, Taxus spp.; Japanese umbrella pine, Sciadopitys verticillata; red pine, Pinus resinosa; whereas the Australian pitch pine, Pinus nigra; pitch pine, Pinus rigida; Scotch pine, Pinus sylvestris; redcedar, Juniperus virginiana,

common juniper, Juniperus communis; tulip tree, Liriodendron tulipifera; and sour gum, Nyssa sylvatica, were seriously injured. Salt spray injury caused an abnormal quantity of dieback on twigs of birches, wild cherry, and apples in the spring of 1939.

The hurricanes "Carol","Edna", and "Hazel" of 1954 and "Diane" and "Ione" of 1955 dropped sufficient quantities of salt spray to cause complete defoliation of some plants and to produce necrotic spots on others. Leaves of the chinaberry and paper-mulberry were noticeably curled and varied from a lighter than normal green to almost white. They had the same appearance as if they had been blanched with scalding water.

The pine needles showed two types of injury. Most of the needles were red-brown and dry appearing; others were distinctly whitened and rather soft. The whitened needles were observed less than 24 hours after hurricane "Hazel" (Oct. 15, 1954). This injury was probably caused by the salt water carried by this storm. If such was the case, then the drier, dark-brown needles were injured by the June storms, either "Carol" or "Edna". The pine plantation near Salvo has experienced salt spray injury many times, probably from the time it was planted. The terminal buds have been killed and this has caused dwarfing and abnormal branching. This plantation (Fig. 8) shows a definite crown profile which is low on the ocean side and increases in height away from the ocean. The pines farthest inland have a nearly uniform height. The pines closest to the ocean are stunted and about half of them have died. In many trees, one or more of the main branches are dead.

Observations in October, 1954, revealed that the figs were mainly leafless. The few remaining leaves did not have any clear-cut spray injury symptoms. Some of the necrotic areas could be the result of fig

leaf diseases. Old pecan leaves had considerable quantities of brittle, dark, brown necrotic tissue, and the new growth, about two-thirds grown, was curled and light green in color. The trees had less than one-third their normal complement of old leaves. A single Japanese walnut tree in the town of Manteo was leafless and the tips of the pointed fruits were blackened. A nearby black walnut was also leafless.

The following is a brief summary of the injuries observed in 1954:

Plants showing salt spray injury	Type of injury to leaves
Arundinaria tecta	yellowish, necrotic margins
Baccharis halimifolia	curled, brownish
Broussonetia papyrifera	curled, lighter green than normal
Callicarpa americana	defoliated
Carpinus caroliniana	curled, brown
Carya illinoiensis	partially defoliated, brown, necrotic leaflets; new growth curled, light green
Cornus sp.	curled, brown
Ficus carica	nearly defoliated, spray or disease
Ilex vomitoria	some leaves black, very little visible symptoms
Iva frutescens	withered, then defoliated, branchlets killed
Iva imbricata	rusty brown
Juglans nigra	defoliated
Juglans cordiformis var. ailanthifolia ?	defoliated, fruit tips blackened
Juniperus virginiana	no injury to yellow-brown branches
Myrica cerifera	curled, brown to leafless
Myrica pensylvanica	curled, brown, becoming defoliated
Nerium oleander	slight injury, if any
Panicum scoparium	brown, withered
Persea borbonia	brown, marginal necrosis
Pinus palustris	brown 2/3 to entire leaves
Pinus taeda	brown, also whitish
Populus nigra var. italica	partly defoliated, leaves brown
Pyrus communis	mainly defoliated, blackened
Prunus sp.	brown to partly defoliated
Punica granatum	curled, brownish
Quercus virginiana	brown, shedding; other leaves on same tree apparently normal
Rhus radicans	brown, necrotic areas between veins
Robinia pseudoacacia	nearly defoliated, curled, lighter green than normal.
Smilax sp.	necrotic margins
Ulmus parvifolia	nearly defoliated
Vitis rotundifolia	withered leaves

The writer traveled from the Norfolk airport to Manteo the day following hurricane Hazel in October, 1954. Salt spray injury was not observed until near the lower end of the Currituck Peninsula. The same area was visited in October, 1955, after three storms, the last of which was in September. Trees and shrubs in the vicinity of the Norfolk airport were injured. The leaves of the Indian azaleas were curled and brown. Large post oaks in the nearby park had curled and whitish leaves. Many of the trees were producing a new crop of leaves which were less than one-third normal size. The injury at Norfolk, Va., was not as severe as that observed on Roanoke, Bodie and Hatteras Islands. Abnormal leaves were also noticed on a variety of trees from Norfolk to Elizabeth City. Pecans seemed to be more sensitive than water oaks. In the vicinity of Elizabeth City the injured foliage was in the upper third of the crown for the most part; lower branches and low growing shrubs did not show conspicuous symptoms. In general, the leaves were curled and withered but lacked the brownish color of the plants on the Outer Banks. Peach orchards along the road on Currituck Peninsula were defoliated.

The storm "Connie" of 1955 was scheduled to go inland or pass the Outer Banks about August 8. Its forward progress was retarded and, as a result, stronger than normal winds continued for several days. They carried sufficient salt spray to obscure vision through windshields on cars traveling the road from Nags Head to Buxton on the 8th, 9th, and 10th. Sea oats and other plants on the dunes were drenched completely with the accumulation of salt spray. By the afternoon of August 9, the culms and leaves were changing color, and by the morning of the 10th, were a yellowish-white. Close examination showed mottled white and yellowish areas with no sharp demarcation.

Wind whip, either alone or aided by sand abrasion, shredded the leaves

of the dune grasses, sea oats in particular. Their leaves were a tangle of threads -- vascular bundles -- hanging from the tops of the sheaths.

Elsewhere in this report there is a brief mention of the sheared and malformed tree and shrub crowns which has been attributed to salt spray injury (Figs. 8, 18, 39, 40). This form of injury was first recognized and described for the Carolinas by Wells and Shunk (1938) and by Wells (1939). They believed the espalier growth form was caused by the toxic action of salt spray only on tender buds. They presented evidence to show that there was more salt on the windward than on the leeward side and thus the developme of protected buds on the lee side resulted in these peculiar growth forms. They also recognized a gradation in degree of tolerance or susceptibility to salt spray, and arranged the following woody species in order from most tolerant to most sensitive: Silverling, yaupon, wax-myrtle, live oak, and loblolly pine. The effective zone of salt spray toxicity was reported as 0.1 to 0.3 of a mile wide, except at Kitty Hawk where this zone was 1.35 miles wide.

Oosting (1942, 1945, 1954) reported on trapping salt spray experimentally and concurs in this general concept.

Boyce (1954) studied the same problem in the Cape Fear area and in New England. He concluded that salt spray alone caused the espalier growth form.

Live oaks at Jefferson Island, La., growing in the path of the fume drift from the salt water evaporators, have hundreds of small, short branches in the lee side but the windward side is without these small branchlets. This seems to substantiate in part the concepts of Wells, Oosting, and Boyce. Prior to the studies of Wells and Shunk, most people referred to these malformed trees as "windswept" and many still do. There is considerable mention in the botanical literature that prevailing winds shape trees.

Alpine trees, many miles inland, both in the United States and in Europe, (where they are known as "Krummholz") show similar one-sided growth forms. At high elevations these forms are attributed to the fact that action of wind dehydration kills buds as the "flag" growth points away from the direction of prevailing winds. Some authors have called attention to the possible action of frosts in killing the buds on the windward side. Some of the apple orchards in the flat area between Buffalo and Rochester, N. Y., have conspicuous one-sided crowns.

It is difficult for the writer to separate, as the primary cause of injury, any one of the components -- whether mechanical wind bending, wind dehydration, sand abrasion, frosts, or salt spray toxicity is to blame. The rather uniform browning over a considerable portion of the hurricane paths in New England following "Carol" suggests that wind dehydration must be considered. It also seems likely that killing of the buds and formation of malformed trees and shrubs results from the combined action of at least wind dehydration and salt toxicity. Strong winds aid materially in transporting salt spray beyond the normal fallout area.

Certainly the major item to be gained from these observations is that salt spray toxicity is a limiting factor on the use of plants for revegetation of the Outer Banks. Most broadleaf, deciduous trees such as white oak, water oak, black locust, elms, redgum, pecan, and paper mulberry are less likely to survive than are the broadleaf evergreens such as live oak, yaupon, wax-myrtle, and gallberry. Even these are injured, dwarfed, and, at times, killed outright.

Native pines such as shortleaf, loblolly, and longleaf withstand

salt toxicity better than deciduous hardwoods. They do not seem to be as resistant as the maritime pine and pond pine. However, pond pine grew farther from the beach than the maritime plantings and thus its degree of resistance is not fully known. Redcedar, although killed at times, is more resistant than loblolly and longleaf pines.

Hurricanes are usually accompanied by heavy precipitation. The storm of 1953 was a "dry" storm on Ocracoke Island. The salt spray therefore was not washed off and large redcedars, 16 to 24 inches in diameter, died following the storm. It is to be expected that all forms of vegetation will be severely injured by a storm of this type.

PLANT MATERIALS FOR SAND BINDING

A. Native and Naturalized Plant Materials

The survival of planted stock depends upon many factors such as season of planting, moisture content of the site, exposure, method and care of planting stock as well as the species used and their adaptability to the site. Their salt tolerance is another vital factor. Although not directly related to survival, fires must be prevented if plantations are to fulfill their objective.

Stratton & Hollowell's data on survival and death of wax-myrtles show a good survival on moist sites and poor survival on crests and slopes of dunes. Likewise, survival is better on grassy flats as compared to bare sand flats. Most woody species follow this pattern, thus indicating where survival will be best. Their data show that most trees and shrubs can be planted from October into April. October and November plantings should be planned carefully as November is a low rainfall month and desiccation is disastrous to newly-set plants.

Although they used native species, more consideration must be given to their susceptibility to salt spray. The more tolerant species can be planted closer to the beach but susceptible species should not be used at all or else planted in limited quantities. It was not possible, in this brief reconnaissance, to locate all species planted; consequently the absence of some of these plants from the lists should not be considered evidence that they finally succumbed. However, in view of the toxicity of salt spray and the general physiography of the environment, tender, broad-leaved plants such as sweet gum, black locust, white oak, red maple, willow, and persimmon should not be planted close to the beach. Cypress is likewise unsuitable. Such conifers as shortleaf, loblolly,

slash, and longleaf pines are seriously injured and, at times, killed by the salt spray. Yet, shortleaf and loblolly pines thrive in the Buxton Woods. They are sufficiently far from the beach that they escape the usual daily fall out of large spray particles. Redcedar grows fine in some places and is injured in others. It should not be planted close to the beach. These conifers are not as useful for revegetating the Outer Banks as are live oak, wax-myrtles, gallberry, and yaupon.

It must be stressed that the most valuable woody plants, such as live oak, wax-myrtles, and yaupons were used in the 1936-40 program. These are broad-leaved evergreens with attractive foliage. The red, black, and gray fruits of yaupon, gallberry, and wax-myrtles contrast nicely with each other and with the color of their respective leaves. These latter plants can be sheared, pruned, cut off at ground level, are relatively tolerant to salt spray, and will sprout again after fire has burned their tops. Such plants grow well on the Outer Banks and should be the basic woody material for landscaping and sand stilling. In addition, such grasses as American beachgrass, sea oats, saltmeadow cordgrass, and Bermuda grass are of prime importance in sand stilling and dune fixation.

The following commentary gives additional information on some of the above-mentioned species as well as additional species which have merit. Their propagation and planting will materially aid the revegetation of the Outer Banks.

Rhizomes and clump divisions were used to plant much of the grass on the Outer Banks. The reasons for this were lack of seed, the fact that divisions would have a better survival chance than seedlings, and because several kinds of grasses were available nearby for the digging.

Sea oats, Uniola paniculata, was one of the species planted (Fig. 14).

Stratton & Hollowell reported that it did not produce seed which meant that its propagation must be carried out by vegetative divisions. Although there is no definite record of the quantity of sea oats planted, they reported that, for one typical five months' period, 18.4 acres of sea oats were used in comparison to 152.4 acres of American beachgrass and 231.4 acres of cordgrass (saltmeadow cordgrass). If the same proportion was used throughout the project, it would mean that a relatively small amount of sea oats was used. Today, however, sea oats is probably the most abundant grass on the dunes from Nags Head to the tip of Hatteras. The great abundance of this species on the Outer Banks suggests that it was used more extensively than the above figures indicate or that it is self sown by seeds. Hitchcock and Chase's (1950) book on grasses was examined for information on seed production in this species. They report that sea oats does not produce pollen or viable seed.

This genus is characterized by the presence of two to four empty lemmas below the fertile florets. These sterile lemmas lack a palea. Spikelets of the August collection were examined just prior to anthesis and the middle florets of the spikelets had a pistil and three stamens with normal appearing pollen. The florets hnd ovaries about three to four times larger than the anthers and the storage of starch had begun. There is every reason to believe that ovaries of this character would develop. This inflorescence was collected in August, just two days before the appearance of hurricane "Connie". During the hurricane the plants were drenched with a coating of salt spray from the heavy surf. Whipping winds of the hurricane stripped most of the spikelets from the axis of the inflorescence, especially in exposed areas. September collections made in Florida showed that the ovaries had matured

to the point of becoming "seed." The spikelets in the October collection from Hatteras had withered ovaries, smaller than those in the August collection. It appears that failure of sea oats to set "seed" may be related to the quantity of salt spray they intercept, and may possibly account for the belief that sea oats are sterile. It is the writer's belief that, if no serious storms occurred, there would be a good crop of "seed", thus contributing to the abundance of this plant on the outer dunes. The plasmolizing effect of the salt spray could readily dehydrate the ovary and pollen.

It should also be mentioned that there is relatively little sea oats in the sand flats between the dunes and the marsh which suggests that either the surface is not suitable for survival of seedlings or that "seeds" do not reach this area. There are occasional small patches on small dunes or high spots along the sound side.

American beachgrass (Fig. 13), an outstanding sand binding grass, was used extensively in the planting program of 1936-40. It has a vigorous, creeping rhizome system as well as the ability to root from upper culm nodes as sand accumulates to form dunes. It is readily propagated by division of the clump and by the numerous rhizomes.

Running beachgrass, Panicum amarum, (Fig. 15) can be recognized by its silvery-green color and the fact that it produces individual culms at each node of the extensive, creeping rhizome system. It puts out numerous rhizom five to six feet long, and has an extremely fine mass of roots at each node. This species is very abundant on the Outer Banks. Planting stock can be obtained by "raking" the sand. The plant produces "seed" as seedlings or viviparous plantlets have been found around the base of the mother plant. It forms nice grass caps to dunes, but the foliage is sensitive to salt spray.

Silver bunchgrass, Panicum amarulum, is a close relative of the above species. It grows in dense clumps with many culms and, in addition, has an extensive rhizome system. This grass is very abundant from the state line south to Nags Head, becoming less abundant southward. It is found occasionally on Bodie Island and Pea Island, but is apparently rare on Hatteras. It will grow in quite dry sand, perhaps drier than the running beachgrass does.

The vegetative portion of knotgrass, Paspalum vaginatum, responds to variations in moisture conditions. On moderately dry sand it forms a close mat with a leaf arrangement similar to that of Bermuda grass. On wet sites, where water may stand an inch or two deep or very close to the surface, the aerial culms may attain a height of ten to fourteen inches. It produces an abundance of rhizomes and stolons, frequently four to eight feet long, and, at each node develops a dense mat of fine rootlets two to three inches long. Although it produces more foliage on moist sites, it does well on moderately dry sand. Along the sound it is one of the grasses which resists wave action and for that reason is valuable for retarding shoreline erosion. It tolerates a fair degree of salinity, but makes better growth in fresh water areas. The grass has carpeted the road shoulders and ditches along the black topped road between Manteo and Hatteras. It spreads rapidly and is abundant in places where the grading machines shaped the road shoulder and ditch in the fall of 1954 after hurricane "Hazel". In several places this grass has formed sufficient turf along the road so that a car can pull off on it without becoming bogged down in the sand (Fig. 44). This is one of the best finds of a native grass for sand binding. It will make a lawn grass on the sand flats if started during the wet months. It can be raked or dug as sod. The seed heads are small and

the quantity of seed produced is small, so that the best method of propagation is by means of stolons and rhizomes. The fruiting inflorescence consists of two conjugate racemes, straight at first, but bowed outward at maturity and nearly touching at the apex, or drooping. The Bermuda grass seed head differs in that it consists of four to six racemes which radiate from the central axis like spokes of a wheel.

Saltmeadow cordgrass, Spartina patens, is primarily a salt marsh grass under Louisiana conditions. However, on the Outer Banks it is more abundant on the sands than in the marshes. It has an extensive rhizome system and grows reasonably well on the smaller sand dunes. It was noticed that stand density decreases with increase in elevation or dryness of the sand to a point where this grass is not efficient in sand stabilization. Under these conditions it apparently takes much longer to get a cover than it does on moist sand. This grass is one of the important pioneers in invasion of moist sand flats. This is best seen on the extreme southwest tip of Hatteras where storm tides regularly flood the sand. Small colonies, a few feet wide and several feet long with only a moderate stand density, have trapped several inches of sand (Fig. 45). Thus it is evident that close planting could result in stabilization of sand and eventual formation of small dunes.

Purple love grass, Eragrostis spectabilis, is a perennial, native grass which has appeared in the sand flats after sand movement was retarded. This grass is frequently viviparous in that plantlets are produced in the inflorescense in place of normal grass fruits, and aid in spreading the plant. It is a grass worthy of additional study as a sand binder. It is perhaps of secondary importance.

Switch grass, Panicum virgatum, grows in dense clumps. It is locally abundant in shallow depressions and has a good sand binding root system. It

can be propagated by division of the clumps and also produces an abundance of fruit.

Glaucous wild-rye grass, Elymus virginicum var. halophilus, grows in dense colonies in the sand flats along the sound side of Currituck Banks. A close relative of this species has been used in sand fixation in other sections of the United States. It can be propagated by dividing the plants.

The rush, Juncus scirpoides, is very abundant in ruts and old roadways through the sand flats. Although it is probably of secondary importance, its ability to grow most profusely in this unfavorable habitat suggests that it should be investigated for its sand binding possibilities.

Silverling, Baccharis halimifolia, is a semi-evergreen, native shrub which has invaded the higher parts of the black rush marsh and the moist but not wet depressions of the sand flats. It tolerates considerable soil salinity and some salt spray. Although the foliage and upper branches may be killed or injured by salt spray or cold weather, it recovers quickly. The plant is not attractive until it produces the silver-colored bristles (parachutes) which are attached to the fruits in the fall, at which time it is conspicuous and attractive. These wind-dispersed fruits could be collected at maturity and seedlings could be raised for planting stock. Stem cuttings will root and it may also be possible to grow plants from root cuttings.

Seashore elder, Iva imbricata, is a low, spreading, semi-evergreen shrub, usually less than two feet tall, with a succulent foliage. It forms large clumps (Fig. 41) and grows well in the dunes. It has an extensive root system. The plants stand considerable sand burial. This native shrub is a volunteer on dunes from Virginia to Ocracoke.

It produces seeds and can be propagated by divisions. It would be worthwhile to determine if stem cuttings root easily.

Bluejack oak, Quercus incana, is a "scrub" oak which grows well in the deep sands on Roanoke Island and is common in the Cape Henry, Va., area. The failure to find it on the Outer Banks may indicate that it is too sensitive to salt spray to be used in exposed places.

Pond pine or marsh pine, Pinus serotina, grows well in the pocosin habitat on Roanoke Island and on the mounds in the black rush marshes adjacent to Roanoke Sound, along with shortleaf and loblolly pines. The visit in October, 1956, after three major storms, showed that this pine is not as sensitive to salt spray as shortleaf, loblolly, or longleaf pines. The foliage on the latter species was brown but the leaves on the pond pine were green. This was very conspicuous on Roanoke Island. This pine should be tried on the Outer Banks but in limited quantities, because most of the sand flats are not optimum sites for this species. It can grow on sites that are too moist for loblolly pine.

Yellow jessamine, Gelsemium sempervirens, is frequently found in thickets and woods on Hatteras, Bodie, Roanoke Islands, and on the Currituck Banks. This is a native, evergreen vine with sweet-smelling, attractive yellow flowers. It blooms from March into April and grows vigorously in the wooded dune sections, producing a network of fine roots.

The orange trumpet creeper, Campsis radicans, is a native, deciduous vine with attractive, orange-red flowers, and is grown as an ornamental to a limited extent in some parts of the southern states. It is aggressive and can become a pest. However, this characteristic makes it valuable for sand stabilization. It is making fine growth on the Outer Banks in many places from the state line to Ocracoke. It possesses another important trait.

Back of Nags Head the Seven Sisters dunes are invading the forest and, in two or three places, have almost reached the sound. In regions where sand burial of twelve to twenty feet has caused the death of hickory and other trees, this vine still lives because it has the ability to put out a succession of roots at different levels in the sand. It produces a large quantity of flat, winged seeds in a cigar-shaped pod. Stem cuttings root easily.

The muscadine or scuppernong grape, Vitus rotundifolia, and the fox grape, Vitus labrusca, also have the ability to withstand deep sand burial. Both of these plants can be propagated by rooting stem cuttings. Their leaves are readily killed by excessive salt spray without injury to the stems.

The cross vine, Bignonia cruciger, is a native evergreen vine. It can withstand being buried in the sand as was seen in Buxton Woods. It is not as vigorous as the orange trumpet creeper, but is worthy of encouragement because of its attractive maroon and yellow blossoms.

Coral honeysuckle, Lonicera sempervirens, is a native vine with attractive red flowers and evergreen foliage. It blooms from late March into May. It has been found in Buxton Woods, Nags Head Woods, and on the wooded dunes between. Although it is not as aggressive as the Japanese honeysuckle, it is thriving in deep sand. It can be propagated by seeds and rooted stem cuttings as well as by division of the crown. This is also a desirable ornamental and can be used in landscaping the Fort Raleigh area and other Park Service installations.

Japanese honeysuckle, Lonicera japonica, is a pest over most of southeastern United States. It is present in varying quantities in the wooded thickets from Frisco to Nags Head and northward. It produces

an abundance of fine roots which make it desirable for sand binding. Vine cuttings can be easily rooted. It usually produces a quantity of black berries which are eaten by birds and this factor aids in spreading the plant in many areas.

Hercules Club, Zanthoxylum clava-herculis, is a large shrub or small tree which is common and widely distributed along the sea coast. It is reasonably tolerant to saline soils but the foliage may be injured by salt spray. It is one of the important woody plants on some of the sound side dunes and its possibilities should be investigated more because of the above mentioned characteristics. It also has ornamental possibilities inasmuch as the bark has an unusual warty appearance. It produces a large quantity o small, black seeds which would make it possible to raise seedlings in quanti

Beach heather, Hudsonia tomentosa, is a northern dwarf shrub of sandy soils which reaches its southern limit of distribution on the Outer Banks. It was seen only on the interior sand flats west of Nags Head. This is a low-growing, compact shrub, seldom a foot high. It should be investigated for its ornamental possibilities because of its dwarf stature, gray-green color, and compact growth. Its root system is such that it thrives on compacted sand. It is a native which is apparently self-sown.

Gallberry, Ilex glabra, is a native shrub with evergreen, pale yellow-green leaves, black fruits, seldom exceeds four feet in height. It forms large clumps as the result of numerous root suckers and is common on the flats of Roanoke Island and Bodie Island near the lighthouse. Its value lies not only in its dense root mat but also in its ornamental possibilities as it has attractive foliage, myriads of tiny, white flowers and black fruits. It is apparently a volunteer from seeds but can be propagated from root cuttings.

Wild bean, Strophostyles helvola (?), is a member of the legume family, an annual that produces long, creeping stems which mat on the ground and climb up on the sea oats or other vegetation as does the perennial Kudzu. It is widely distributed from Ocracoke to Bodie Island and northward. It is obvious that seeds of the plant are self-sown and, under proper conditions of moisture and sand stability, it establishes itself readily. Positive identification was not possible because it was not in flower or fruit at the time of these field studies. The foliage is similar to that of Strophostyles. Miss Rondthaler (1952) collected a wild bean on Ocracoke which was identified as Phaseuolus polystachys. This plant could be either species. Stems of these plants are annual and thus propagation is chiefly by seeds. If seeds were scattered on the surface of semi-stable sand with the proper moisture, a good ground cover would soon develop.

Three species of yucca grow on the Outer Banks. The native spoonleaf yucca, Yucca filamentosa, can be recognized by a rosette of leaves nestled on the ground, and by the cupped apices of leaves with threads along the sides of the leaves.

Spanish Dagger, Yucca gloriosa, has a short trunk, three to four feet tall, with a flower cluster on a naked stalk which projects above the leaves. (Fig. 46).

Spanish yucca, Yucca aloifolia, has an erect trunk, six to eight feet tall, with the flower cluster partly seated within the apical leaves.

These plants all have extensive long, cord-like roots which eventually become fibrous. They are able to grow in deep sand and are quite resistant to salt spray, although the flower cluster may be

injured by the spray. They produce suckers which can be planted and, in addition, trunks of the last two can be cut into segments which root readily and then produce stems. The last two species are common ornamentals which, in many parts, have escaped from cultivation and become a conspicuous addition to the local flora. Although probably introduced into the Outer Banks, they are so widespread that most people consider them native.

B. Possible Introductions

One of the basic premises followed in the sand stilling and dune fixation work in 1936-40 was to use native plants. This was done, and with the exception of certain trees, proved to be very effective. However, some introduced plants could be used to supplement the native vegetation. It does not seem wise to refuse to use a plant which can tolerate sun, sand, salinity and water deficiency just because it is not a native. Bermuda grass is not a native, although it was used in the 1936-40 plantings, and it has become so completely naturalized in the southeastern United States that many, who know it as "wire grass", do not know that it is an introduced plant. Fig trees are included in the landscaping plans for the walk back of the Museum Building on Bodie Island, but they are not native plants.

St. Augustine grass, Stenotaphrum secundatum, is well known as the grass which is able to grow on the barren Florida sands, both inland and along coastal areas of low salinity. It should grow as well on Hatteras as it does in areas of Louisiana which are much colder. This grass is propagated by cuttings of the stolons and rhizomes, so would necessitate the establishment of a grass nursery in order to raise sufficient quantities for planting. It grows abundantly in the vicinity of Wilmington, N. C., and has been used at Moorhead City, N. C. (Blomquist, 1948).

Panicum repens is a good sand binder in the saline sands along the Gulf Coast from Florida to Texas. It can recover from successive sand burials. The disadvantage of this species is that Hatteras is far from the source of supply.

There is one big clump of "Australian Pine", Casuarina equisetifolia, about twenty feet tall in the yard of Mrs. White in the Buxton Woods area. She believes that the plant is about twenty years of age. This plant has been very valuable in Florida for windbreaks, hedges, and ornamental plantings on sand, both in the interior and along the coast. It is very adaptable and can be trimmed and left as a hedge or allowed to grow as a tree. At times, in Florida, it is something of a pest in that it produces quantities of root suckers and can take over a small yard or garden. Although this area is farther north than it usually grows, its presence on the Outer Banks, along with orange and grapefruit trees, indicates relatively mild winters. It did not show any salt spray injury in October, 1954; however, a considerable portion of the top was brown in April, 1955 -- probably the result of the abnormally cold winter. It might be worth trying in some cases.

Oleander, Nerium oleander, was planted at Cape Hatteras Lighthouse rangers' quarters and appears to be growing satisfactorily there as well as in Buxton, Hatteras, and Manteo. The foliage did not show any salt spray injury in the fall of 1954. However, some of the leaves showed injury by April, 1955, which might be the result of cold weather. It is one of the feature attractions on saline sands of Grand Isle, La., and Galveston, Texas. It is available with white, pink, red, or yellow flowers, either single or double. Young children have been poisoned from eating its foliage and this feature should be considered in

selecting planting sites.

Kudzu, Pueraria thunbergiana, is a well known vine which is widely used in the southern states for soil binding and forage. It grows on the sound side along the road to Colington Island where it is making excellent growth, as well as in the sand at another site two or three miles away. It has covered the sand with a network of stems from which it sends out a quantity of roots at each node. It is easily established with vine cuttings which are readily obtained in most southern states. The large leaves, however, do show salt spray injury.

Euvonomyous, Euvonymus japonicus, is an evergreen shrub, usually under six feet tall. It is widely planted in the villages of Hatteras, Buxton, Avon, Manteo, and on Okracoke Island. The outstanding advantage of this plant is that it does not show any salt spray injury whereas nearly all other nearby ornamentals do. Also, this shrub appears to grow readily in the sand.

Tamarisk or salt cedar, Tamarix gallica L., and its close relatives are adapted for arid and saline areas. Coker and Totten (1937) mention that this species has escaped from cultivation in the neighborhood of Beaufort, N. C. Here it was used soon after the Revolution to hold banks of the causeways through the salt marshes. There is a tree at Beaufort which is more than 90 years of age. This plant, although naturalized, should be considered in the planting program because it is well adapted to many locations on the Outer Banks.

A. Y. Goor (1935) discusses the collection, storage of seed, development of a nursery, different planting practices in aforestation and reforestation of arid areas of the Near East. He recommends the use of potted plants over bare-rooted stock on the basis of better survival. Direct

sowing in rows or pockets has been successful if the seed bed has been properly prepared. However, direct seeding of sand dunes has failed. His comments about sand fixation agree with what has been observed on the Outer Banks. He found that "The basic principle in sand-dune fixation is to prevent the sand from moving long enough to enable either natural or planted vegetation to establish itself." He also mentions that "Natural vegetation will invade the dunes only if their movement is completely checked and if there is sufficient vegetation in the vicinity to seed itself."

The following plants have been selected from his list of plants, along with his comments, as ones which would probably grow on the Outer Banks.

Acacia cyanophylla	The best species to use for binding moving sand.
Acacia cyclops	A very useful plant for binding coastal sand dunes.
Ammophila arenaria	The most successful grass in binding sand dunes.
Casuarina equisetifolia	A littorial species which grows best on loose sand near the sea shore.
Casuarina glauca	It grows along tidal creeks, and sometimes in salt water and is more adaptable to adverse weather and soil conditions than C. equisetifolia.
Eucalyptus gomphocephala	Tolerant up to 5000 parts per million of salinity.
Eucalyptus occidentalis	Tolerant up to 5000 parts per million of salinity.
Eucalyptus cornuta	Tolerant up to 5000 parts per million of salinity.

Pinus pinaster	Although widely successful in afforestation of coastal sands, it has not been successful in the near eastern region.
Tamarix articulata	Strongly resistant to salt and drought.

CATALOGUE OF PLANTS OBSERVED ON THE OUTER BANKS

The following list of plants was prepared from observations made on four trips to the Outer Banks and represents the results of only 19 days in the area. It was possible to prepare this catalogue with only limited field work because the writer could identify the majority of plants on sight in the field as the results of his knowledge of the same species in Louisiana. It was not possible during such a reconnaissance to collect extensively and cover the entire area. A few important unknown plants were collected to determine their identity. These were taken mainly in August, 1955.

Intensive collecting will not only add many species to the appended list but also establish the identity of plants listed herein with a question mark. The best collecting period should be between the middle of June and the middle of August.

As mentioned above the flora is predominately southern in that the general range of these plants is from Texas to Florida and northward to Virginia and Delaware. This is exemplified by such woody plants as live oak, yaupon, hercules club, muscadine, supple-jack, water oak, and palmetto. Such herbaceous plants as sea oats, wind-mill grass, whitetop sedge, resurrection fern, black rush and Spanish moss have a similar distribution pattern.

Some plants such as saltmeadow cordgrass, smooth cordgrass, and big cordgrass have a wider range along the Atlantic coast from Maine to Florida. The beach heather and American beachgrass are two species of a smaller group that are characteristically northern in their distribution and reach their southern limits on the Outer Banks. The cranberry in the peat bogs on the mainland is also a distinctly northern species.

The native flora has been augmented by the introduction of many ubiquitous European weeds. There are several species of ornamentals which have no yet escaped from cultivation. These have been listed because they are suitable for the area.

Certain other correlations can be made about the distribution of vegetation of this region. One cannot help being impressed with the similarity between the vegetation of Currituck Peninsula and that portion of Currituck Banks between the Wright Memorial Bridge and Nags Head Woods. The distribution of beech, for example, strongly suggests the flora of this latter area is in reality a continuation of that of Currituck Peninsula.

Likewise the characteristic elements of the pocosin flora of Roanoke Island are different from those of the Outer Banks. The pocosin flora is duplicated over a considerable portion of the mainland of North Carolina. However, the adjacent mainland flora between Stumpy Point and Manns Harbor is not exactly similar to the pocosin flora of Roanoke Island. This is probably because this section of the mainland has a peaty or organic substratum as compared to the sand substratum of Roanoke Island. The Fort Raleigh portion of this island appears to represent a coastal plain community different from that of the pocosin area.

A large portion of the flora of the Outer Banks, rich in southern species, has no real counterpart on the mainland of North Carolina except as fringes along some of the bays.

Blocks of peat from submerged layers on Ocracoke, Hatteras, and Pea Islands are washed ashore by storm tides. These are very interesting in that they contain pollen of Abies and Picea, northern or high mountain plants which no longer grow in the area. This peat is being studied and the results will be reported at a later date. It is mentioned here because

the writer firmly believes that there is a relationship of northern and southern elements of the present flora to these fossil pollens and the post glacial history of the area. Thus there are many phases of Plant Geography, and Ecology which remain to be unraveled by detailed studies of this interesting area.

The nomenclature of this catalogue follows in general that used by Little (1953) for the trees. The names used for the grasses are those used in Hitchcock and Chase (1950) and the remainder of the plant names follow those used by Fernald (1950). Names marked with an asterisk (*) are of plants which are ecologically significant for their respective habitats.

The flora is composed of some 95 families, 273 species plus some 36 entries in which one or more species could not be positively identified in the field. The total flora will probably number close to 400 species.

Division PTERIDOPHYTA, Ferns and Fern Allies

LYCOPODIACEAE, Club-moss Family

Lycopodium alopecuroides L. foxtail club-moss
Common in pocosin on Roanoke Island and in pineland bogs between Manns Harbor and Stumpy Point on the mainland.

OSMUNDACEAE, Flowering Fern Family

Osmunda cinnamomea L. cinnamon-fern
Local, in boggy depressions, Nags Head Woods.

Osmunda regalis var. spectabilis (Willd.) Gray royal fern
Locally abundant, brackish marshes on Currituck Peninsula, moist depressions in Nags Head Woods, and margin of fresh water ponds Bodie and Hatteras Islands.

POLYPODIACEAE

Asplenium platyneuron (L.) Oakes ebony spleenwort
Frequent, in moist woods at Buxton, Bodie Island and Nags Head Woods.

Dryopteris normalis C. Chr. southern shield fern
Rare, boggy depression in Nags Head Woods.

Dryopteris thelypteris (L.) Gray marsh fern
Common on margin of brackish to saline marshes, Currituck Peninsula, Bodie and Hatteras Islands.

Polypodium polypodioides (L.) Watt resurrection fern
Local on trees in Nags Head Woods.

Pteridium aquilinum var. pseudocaudatum (Clute) Heller bracken
Locally abundant in pocosin, Roanoke Island, scattered on Bodie and Hatteras Islands in margin of sand-flats.

Woodwardia areolata (L.) Moore netted chain-fern
Occasional in moist shady places, margins of ponds, Nags Head Woods, moist thicket near Bodie Island Lighthouse and Buxton Woods, Hatteras Island.

Woodwardia virginica (L.) Sm. Virginia chain-fern
Very abundant in bogs and pineland along road from Stumpy Point to Manns Harbor, locally abundant in pocosin on Roanoke Island.

Division SPERMATOPHYTA, Seed Plants

Subdivision GYMNOSPERMAE

PINACEAE, Pine Family

Chamaecyparis thyoides (L.) B.S.P. southern white cedar
Very abundant, mainland peat bogs between Manns Harbor and Stumpy Point.

*Juniperus virginiana L. redcedar
Large trees were locally abundant on wooded dunes from Ocracoke to Virginia. It is one of the chief stumps of the Wash Woods area, Currituck Banks. It was extensively planted at Corolla, N. C., however it is slow growing. Salt spray from the hurricane of 1933 killed many big trees on Ocracoke Island.

*Pinus echinata Mill. shortleaf pine
A large tree about 30 inches in diameter was noted in Nags Head Woods. Common Roanoke Island and occasional in Buxton Woods: present in pine plantation near Avon, Hatteras Island.

Pinus palustris Mill. longleaf pine
Planted in sand-flats, Rodanthe and Avon on Hatteras Island.

Pinus pinaster Ait. maritime pine
Introduced from Mediterranean region and planted on sand-flats in vicinity of Corolla, Currituck Banks, Bodie and Hatteras Island 1936-1940. Easily killed by fire. Now producing seeds and becoming naturalized near Cape Hatteras Lighthouse. More resistant to salt spray than native pines.

*Pinus serotina Michx. f. pond pine, marsh pine
Common Roanoke Island and mainland between Stumpy Point and Manns Harbor.

*Pinus taeda L. loblolly pine
Common on Currituck Peninsula, near Wright Memorial Bridge, Colington Island, Nags Head Woods, Roanoke Island, and Buxton Woods, Hatteras Island; planted near Avon and in vicinity of Corolla.

*Taxodium distichum (L.) Rich. baldcypress
(including variety nutans)
Scattered trees were seen along the margin of the marsh on Currituck Peninsula, Wright Memorial Bridge, Colington Island and Nags Head Woods, Roanoke Island and the mainland near Manns Harbor. Trees with foliage typical of var. nutans were observed in depressions in the pocosin south of Manteo, Roanoke Island.

Thuja orientalis L. oriental arbor-vitae
Cultivated on Roanoke and Hatteras Islands.

Subdivision ANGIOSPERMAE

Class 1. Monocotyledoneae, Monocots

TYPHACEAE, Cat-tail Family

*Typha angustifolia L. narrow-leaved cat-tail
(and/or domingensis Pers.)
Locally common in moist habitats, margins of marshes, from Virginia to Ocracoke Island.

*Typha latifolia L. common cat-tail
Locally common around fresh water ponds, depressions and margins of marshes, often with Typha angustifolia from Virginia to Ocracoke Island.

ZOSTERACEAE, Pondweed Family

*Ruppia maritima L. widgeongrass
Widespread in pools from Currituck Sound to Ocracoke Island.

*Zostera mariana L. var stenophylla Aschers. & Graebn. eelgrass
A disease nearly destroyed this important duck food several years ago. It apparently is coming back. Considerable quantities of leaves and stems are washed ashore and mark storm and normal tide lines. Ocracoke, Hatteras, Pea, Bodie Islands and Currituck Banks.

ALISMATACEAE, Water-plantain Family

Sagittaria latifolia Willd. duck-potato
Frequent in marsh along Currituck Sound.

GRAMINEAE, Grass Family

*Ammophila breviligulata Fernald American beachgrass
This species is widely distributed on the Outer Banks from Virginia to Hatteras Island. It is locally abundant in places, probably areas where it was extensively planted. This is an important sand binding grass. (Fig. 43).

Andropogon elliottii Chapm. (?) elliott beardgrass
Occasional plants with big bracts in inflorescence on sand-flats, obviously not A. glomeratus, virginicus or littoralis. Hatteras Island.

*Andropogon glomeratus (Walt.) B.S.P. bushy beardgrass
Locally abundant in the moist depressions of sand-flats and on flat-topped mounds, Hatteras, Bodie, Roanoke Islands and Currituck Banks.

Andropogon littoralis Nash dune bluestem
Locally abundant on the outskirts of Manteo, Roanoke Island. Apparently absent from the dune area of the Outer Banks.

*Andropogon virginicus L. slender broomsedge
Common in the dry sand flats on the Outer Banks, from Virginia to Ocracoke Island.

*Aristida sp. three-awn or wire grass
Occasional on sand flats and abundant in pocosin on Roanoke Island.

*Arundinaria tecta (Walt.) Muhl. switch cane
Locally common in the wooded areas. Nags Head Woods, Colington, Roanoke, Bodie and Hatteras Islands.

Arundo donax L. giant reed
Planted near the east end of the bridge across Roanoke Sound, Bodie Island.

Cenchrus tribuloides L. sandbur
Widely scattered but not abundant on sand flats, dunes and around habitations.

Chloris petraea Swartz windmill-grass, fingergrass
Frequent and widely distributed in the sand flats and invading margins of dunes on the Outer Banks from Virginia to Ocracoke Island.

*Cynodon dactylon (L.) Pers. Bermuda grass
Extensively planted around the Wright Memorial, and was used in connection with the dune fixation program of 1936-40. Locally abundant around houses and occasional in the sand flats. A good plant for use on the sand flats.

Digitaria sanguinalis (L.) Scop. crabgrass
An introduced weed more abundant around habitations and occasionally invading sand flats.

Distichlis spicata (L.) Greene seashore saltgrass
Rare in the more brackish depressions and margin of salt marsh, Pea and Ocracoke Islands. This should be an important member of the marsh community but it is too rare to be significant.

Echinochloa crusgalli (L.) Beauv. barnyard grass
Frequent around habitations, and occasional in the sand flats and debris zone on the sound side marshes, Hatteras, Bodie and Roanoke Islands.

Echinochloa walteri (Pursh) Heller Walter's barnyard grass
Locally distributed in the contact area between soundside dunes and the Spartina cynosuroides marsh.

Eleusine indica (L.) Gaertn. goosegrass
An introduced weed, persisting around habitations, not abundant.

Elymus virginicus var. halophilus (Bickn.) Wiegand glaucous wild-rye
Locally abundant in moist sandy areas along the sound from Virginia to Ocracoke Island.

*Eragrostis spectabilis (Pursh) Steud. purple lovegrass
Widely distributed and locally common on the sand flats from Virginia to Ocracoke Island. This perennial grass has fair sand binding possibilities.

Erianthus giganteus (Walt.) Muhl. sugarcane plumegrass
Locally abundant in moist, fresh water depressions on Currituck Peninsula and occasional in moist depressions on Currituck Banks, Bodie and Hatteras Islands.

Festuca octoflora Walt. sixweeks fescue
Occasional in the sand flats, Hatteras Island.

Festuca rubra L. red fescue
Local on sand flats near Rodanthe, Hatteras Island.

*Muhlenbergia capillaris (Lam.) Trin. purple muhly
Very abundant and widely distributed on the sand flats on Roanoke, Bodie, Pea, Hatteras and Ocracoke Islands. This clump-forming grass has a very fine root system and is valuable in retarding sand shifting on the sand flats. As it builds up the habitat it will be replaced by sod forming grasses. (Fig. 48).

Panicum anceps Michx. beaked panic-grass
Occasional in sand along trails in wooded thickets.

*Panicum amarulum Hitchc. & Chase silver bunch grass
This sand and dune inhabiting grass is most abundant on the Outer Banks from Oregon Inlet, northward to Virginia.

*Panicum amarum Ell. running beachgrass
One of the important dune stabilizing grasses which is widely distributed from Virginia to Ocracoke Island.

Panicum dichotomiflorum Michx.
Wet, roadside depressions, Pea and Bodie Islands.

Panicum spp. panic grasses
There are several species of this genus which are locally abundant in the sand flats on Bodie Island and in Buxton Woods, Nags Head Woods and Roanoke Island.

Panicum virgatum L. switch grass
Common but locally distributed in moist depressions in the sand flats and on the margin of the marsh.

Paspalum ciliatifolium Michx.
Occasional on the sand flats and in the woods.

Paspalum dilatatum Poir. dallis grass
An introduced grass, occasional around habitations and along roadsides. Roanoke Island, Manns Harbor to Stumpy Point.

Paspalum urvillei Steud. Vasey grass
An introduced grass, Roanoke Island, Manns Harbor, Stumpy Point, Currituck Peninsula.

*Paspalum vaginatum Swartz smooth knotgrass
An important sand binding grass which grows best in moist places. Abundant near Cape Hatteras Lighthouse in poorly drained sand flats, along road shoulders on Hatteras Island, and along marshes on Hatteras, Bodie, and Ocracoke Islands and Currituck Banks.

Poa annua L. annual bluegrass
An introduced grass, usually on lawns around habitations.

Polypogon monspeliensis (L.) Desf. rabbitfoot grass
Occasional in sand flats on Hatteras Island.

Sacciolepis striata (L.) Nash.
Occasional in the dryer portion of the marshes from Hatteras to Bodie, Roanoke Islands and Currituck Peninsula.

Setaria geniculata (Lam.) Beauv. knotroot bristlegrass
Frequent in sand flats, Ocracoke Island to Currituck Banks.

Setaria magna Griesb. giant bristlegrass
Occasional at the junction of marshes and sand flats and moist depressions from Virginia to Ocracoke Island.

*Spartina alterniflora Loisel. smooth cordgrass
Abundant in brackish to saline marshes from Ocracoke Island to Virginia line. It grows in the sound in 6 to 10 inches of water and to about 6 inches above low tide.

*Spartina cynosuroides (L.) Roth big cordgrass
Common in the fresh to brackish fringe between the marshes and sand flats, along moist depressions, and streams from Virginia to Ocracoke Island. Occasional or locally abundant in black rush marshes on elevations above the general marsh level.

*Spartina patens (Ait.) Muhl. saltmeadow cordgrass
One of the most important and abundant grasses from Ocracoke Island to the Virginia State line. Grows from moist marsh to tops of low dunes.

Sporobolus poiretii (Roem. & Schult.) Hitchc. smutgrass
Introduced; frequent around habitations.

Triplasis purpurea (Walt.) Chapm. purple sand grass
Locally common but widespread in sand flats and invading dunes.

Uniola laxa (L.) B.S.P.
Occasional, in woods, Nags Head, Buxton and Roanoke Island.

*Uniola paniculata L. sea oats
Very abundant from Virginia to Ocracoke Island; usually confined to sand dunes, occasional on low elevations in sand flats. Widely planted in 1936-40.

Zizania aquatica L. annual wildrice
Locally abundant in marshes along Currituck sound, Wright Memorial Bridge, Kittyhawk, and Colington Island.

CYPERACEAE, Sedge Family

Carex spp.
There are several species of Carex on the Outer Banks which may be found around the fresh water pools and depressions, woods and a few on the sand flats.

*Cladium jamaicensis Crantz saw-grass
Very abundant around fresh water ponds, the predominant plant in the marshes between the ridges at the Wright Memorial Bridge, the marshes between the wooded ridges at Buxton, and in the marshes along the sound from Virginia to Hatteras Island.

Cyperus flavescens L. sedge
Locally abundant in depressions in sand flats.

Cyperus retorsus Chapm.
Local along trail in Nags Head Woods.

Cyperus sp.
Several species of sedges occur on the Outer Banks, chiefly around fresh water ponds, moist woods, margins of marshes and occasional in sand flats.

*Dichromena colorata (L.) Hitchc. whitetop sedge
A common sedge which is easily recognized by the white bracts around the flower cluster at the top of the stem. Sand flats from Virginia to Ocracoke Island.

Eleocharis microcarpa Torr. (?)
Rare, bottom of temporary brackish pond, Pea Island.

Eleocharis sp. spike-rush
One or more species in moist depressions in sand flats, Bodie and Hatteras Islands.

Fimbristylis autumnalis (L.) R. & S.
Occasional on sand flats, Virginia to Hatteras Island.

*Fimbristylis castanea (Michx.) Vahl sand rush
Common and widely distributed, shrub margin of marshes, and most abundant in the sand flats from Virginia to Ocracoke Island.

*Scirpus americanus Pers. chair-makers' rush
Locally abundant in sound side marshes, moist depressions and scattered in sand flats, Roanoke, Bodie, Hatteras and Ocracoke Islands.

Scirpus olneyi Gray three-square
Locally common in marshes.

Scirpus robustus Pursh triangle sedge
Frequent in marshes along Currituck Peninsula.

Scirpus rubicosus Fernald
Common along roadside through bogs between Manns Harbor and Stumpy Point.

*Scirpus validus Vahl great bulrush
Common in marsh at east end of Wright Memorial Bridge.

Scleria verticillata Muhl. nut-rush
Widespread, but not common in sand flats, Rodanthe.

PALMAE, Palm Family

Sabal minor (Jacq.) Pers. palmetto
Locally abundant, Buxton Woods, Hatters Island, wooded dunes, Nags Head Woods, and occasional on Roanoke Island.

ARACEAE, Arum Family

Peltandra virginica (L.) Schott & Endl. arrow-arum
Frequent in peat bogs on mainland between Stumpy Point and Manns Harbor.

XYRIDACEAE, Yellow-eyed Grass Family

Xyris sp. yellow-eye grass
Local in moist places in pocosin, Roanoke Island.

BROMELIACEAE , Pineapple Family

Tillandsia usneoides L. Spanish moss
An epiphyte, rare on the Outer Banks, Buxton, Currituck Peninsula and mainland.

COMMELINACEAE, Spiderwort Family

Commelina sp. day flower
Occasional in sand flats from Virginia to Ocracoke Island.

PONTEDERIACEAE, Pickerelweed Family

Pontederia cordata L. pickerelweed
Common in marsh on eastern side of Currituck Peninsula, locally abundant around fresh water ponds and depressions on Hatteras, Bodie and Roanoke Islands.

JUNCACEAE, Rush Family

Juncus dichotomus Ell. rush
Common in sand flats, Hatteras Island

*Juncus roemerianus Scheele black rush
Very abundant, covering hundreds of acres of saline marsh, occasional on sand flats.

*Juncus scirpoides Lam. rush
Very abundant in sand flats from Virginia to Ocracoke Island. It is perhaps valuable as a secondary sand stabilizer. Old roadways in the sand flats can be traced by either a carpet of this plant or compact ribbons of it in the old wheel tracks.

LILIACEAE, Lily Family

Smilax spp. greenbriar, sawbriar
Common and widely distributed, from Ocracoke Island to Virginia, usually in woods, wooded thickets, peaty soils, pocosin, and on sound side dunes. Apparently planted on barrier dune near Cape Hatteras Lighthouse. No attempt was made to distinguish the various species in the field, however, at least S. laurifolia, bona-nox and rotundifolia are represented.

Yucca aloifolia L. Spanish bayonet
Cultivated and persisting or escaping, dunes, and village sites, Hatteras Island.

Yucca filamentosa L. spoonleaf yucca
Locally common Roanoke Island and Whalebone Junction on Bodie Island, where it is both cultivated, indigenous and/or naturalized.

Yucca gloriosa L. Spanish dagger
Cultivated at Waves, Hatteras Island.

AMARYLLIDACEAE, Amaryllis Family

Crinum sp. milk and wine lily
Cultivated in the village of Hatteras, Hatteras Island.

IRIDACEAE, Iris Family

Sisyrinchium sp. blue-eye grass
Widespread in sand flats. Specific identification not feasible in field.

ORCHIDACEAE, Orchis Family

Goodyera pubescens (Willd.) MacM. (?) rattle-snake plantain
Rare under beach trees in Nags Head Woods. Identification based upon foliage only.

Habenaria blephariglottis (Willd.) Hook white-fringe orchis
Frequent in pocosin on Roanoke Island.

Class 2. Dicotyledoneae, Dicots

CASUARINACEAE, Casuarina Family

Casuarina equisetifolia L. Australian-pine, horsetail-tree
Cultivated at Buxton, resistant to salt spray injury; damaged by cold weather winter of 1954-55.

SAURURACEAE, Lizards-tail Family

Saururus cernuus L. lizard-tail
Locally common in moist depressions in woods and occasional at margin of marsh.

SALICACEAE, Willow Family

Populus alba L. white or silver-leaved poplar
Cultivated at Buxton, Hatteras Island and on Roanoke Island.

Populus nigra L. lombardy poplar
Cultivated on Roanoke Island.

Salix babylonica L. weeping willow
Cultivated, Hatteras and Roanoke Islands.

Salix nigra Marsh. black willow
Local around fresh water pool and margin of marshes, Hatteras, Bodie, Roanoke Islands, Currituck Peninsula; and sand flats, between Nags Head and Duck, Currituck Banks.

MYRICACEAE, Wax-myrtle Family

*Myrica cerifera L. wax-myrtle
An important and abundant shrub on dunes and sand flats from Ocracoke Island to Virginia.

*Myrica pensylvanica Loisel. bayberry, candleberry
An important shrub on dunes and sand flats from Ocracoke Island to Virginia, most abundant on Bodie Island. Apparently of more ornamental value than Myrica cerifera.

JUGLANDACEAE, Walnut Family

Carya glabra (Mill.) Sweet pignut hickory
Frequent along road in Nags Head Woods. Too large and old to be part of the hickories planted in 1936-40.

Carya illinoiensis (Wang.) Koch pecan
Cultivated; Currituck Peninsula, Roanoke and Hatteras Islands.

Juglans cordiformis var. ailanthifolia Rehd. (?) Japanese walnut
Cultivated in Manteo, Roanoke Island.

Juglans nigra L. black walnut
Cultivated on Roanoke Island; apparently native on Currituck Peninsula.

CORYLACEAE, Hazel Family

Carpinus caroliniana Walt. American hornbeam
Common in wooded dunes at Buxton, Hatteras Island and in Nags Head Woods.

FAGACEAE, Beech Family

Castanea pumila (L.) Mill. chinkapin
Observed only in Nags Head Woods.

Fagus grandifolia Ehrh. beech
Common Currituck Peninsula, occasional in Nags Head Woods, and at Wright Memorial Bridge.

Quercus falcata Michx. southern red oak
Common on Currituck Peninsula, Nags Head Woods, and Roanoke Island.

Quercus incana Bartr. bluejack oak
Frequent in the deep sand around Fort Raleigh, Roanoke Island.

Quercus laurifolia Michx. laurel oak
Common in Buxton Woods, Hatteras Island, Fort Raleigh, Roanoke Island and in Nags Head Woods.

Quercus marilandica Muenchh. blackjack oak
Frequent in Fort Raleigh area on Roanoke Island.

Quercus nigra L. water oak
Abundant on Currituck Peninsula, frequent in Nags Head Woods, Roanoke Island and occasional in Buxton Woods.

Quercus phellos L. willow oak
Abundant on Currituck Peninsula, common at Wright Memorial Bridge, Colington Island, Nags Head Woods, Roanoke Island and Buxton Woods on Hatteras Island.

Quercus stellata Wang. post oak
Occasional at Powells Point, Currituck Peninsula and at Kitty Hawk.

*Quercus virginiana Mill. live oak
Very abundant as a stunted and dwarfed shrub on sand flats and thickets from Ocracoke Island to Virginia. A large tree on the more protected dunes and sound side dunes over the same range.

ULMACEAE, Elm Family

Celtis laevigata Willd. sugarberry
Wooded dunes at Buxton, Hatteras Island, Ocracoke Island, Roanoke Island, Nags Head Woods.

Ulmus parvifolia Jacq. Chinese elm
Cultivated on Roanoke Island.

MORACEAE, Mulberry Family

Broussonetia papyrifera (L.) Vent. paper-mulberry
Cultivated on Hatteras and Roanoke Islands.

Ficus carica L. fig
Cultivated: Ocracoke Island to Corolla, N. C.

URTICACEAE, Nettle Family

Boehmeria cylindrica (L.) Sw. false-nettle
Occasional in moist locations on sand flats and marshes, Waves, Hatteras Island.

LORANTHACEAE, Mistletoe Family

Phoradendron flavescens (Pursh) Nutt. American mistletoe
Common on a variety of host trees from Hatteras Island to Virginia.

POLYGONACEAE, Buckwheat Family

Polygonum spp. smartweed
One or more species, common in fresh water ponds and moist depressions near Cape Hatteras Lighthouse, Hatteras Island, Currituck Peninsula.

Rumex crispus L. yellow dock
Weed in marsh and roadside Currituck Peninsula.

Rumex hastatulus Baldw. ? sorrel
Occasional weed around habitations and roadside near Currituck sound.

CHENOPODIACEAE, Goosefoot Family

Atriplex patula L. orach
Occasional on machine made dikes as an early invader; also on bare sand subject to flooding by high tides on southwestern tip of Hatteras Island.

Chenopodium ambrosioides L. Mexican-tea
A weed common in sand flats and dike at Avon, Hatteras Island.

Chenopodium album L. lamb's-quarters
Occasional in drift zone on sound side, between Buxton and Frisco, Hatteras Island.

Salicornia bigelovii Torr. dwarf saltwort
Rare, in depression too low and saline for Distichlis spicata, Pea Island.

Salicornia europaea L. chickenclaw saltwort
Rare, with Salicornia bigelovii on Pea Island.

Salicornia virginica L. perennial saltwort
Relatively rare, Hatteras Island and Bodie Island, also reported from Ocracoke Island.

Salsola kali L. Russian thistle
Occasional on flooded sand beach, debris zone on sound side between Frisco and Buxton, Hatteras Island.

AMARANTHACEAE, Amaranth Family

Acnida cannabina L. waterhemp
A minor component of the drier portions of the saline marshes; present on dike around village of Avon, Hatteras Island.

PHYTOLACCACEAE, Pokeweed Family

Phytolocca americana L. pokeweed
Widespread but not abundant in shrub margin of marshes, moist woods and occasional around habitations.

AIZOACEAE

Mollugo verticillata L. carpetweed
An introduced week; occasional around habitations and cultivated ground.

Trianthema portulacastrum L. sea-purslane
Drift zone on sound side between Buxton and Frisco, Hatteras Island.

CARYOPHYLLACEAE, Pink Family

Cerastium vulgatum L. mouse-ear chickweed
An introduced weed; frequent in vicinity of habitations and old cultivated fields.

Paronychia virginica Spreng. whitlow-wort
Occasional in sand flats, Hatteras Island.

Spergularia marina (L.) Griesb. sand-spurry
Seen only on clay island in Roanoke sound.

Stellaria media (L.) Cyrillo common chickweed
An introduced weed around habitations, cultivated fields.

NYMPHAEACEAE, Water-lily Family

Nuphar or Nymphaea ? waterlily
Frequent in fresh water pools, Hatteras and Bodie Islands. Flowers and fruits were not seen and thus positive identification was not possible.

RANUNCULACEAE, Crowfoot Family

Ranunculus sp.
Around margin of fresh water pond near Bodie Island Lighthouse.

MAGNOLIACEAE, Magnolia Family

Magnolia grandiflora L. southern magnolia
Common in cultivation on Roanoke Island.

*Magnolia virginiana L. sweet-bay
Common to abundant, Currituck Peninsula, margins of marshes and on ridges at Wright Memorial Bridge, Nags Head Woods, Colington, Roanoke, Bodie, Hatteras, and Ocracoke Islands.

LAURACEAE, Laurel Family

*Persea borbonia (L.) Spreng. redbay
Common around fresh water ponds, wooded dunes, and occasional in low places of the sand flats from Ocracoke Island to Virginia.

Sassafras albidum (Nutt.) Nees sassafras
Locally abundant in wooded areas, Wright Memorial Bridge, Colington Island, Nags Head Woods, Roanoke and Hatteras Islands.

PAPAVERACEAE, Poppy Family

Corydalis aurea Willd. (?) golden corydalis
Occasional plant in drift area on sound side between Buxton and Frisco, Hatteras Island.

CRUCIFERAE, Mustard Family

Cakile edentula (Bigel.) Hook. sea-rocket
A pungent tasting edible herb, common in the drift lines between low and high tides on the sound side of the Outer Banks, occasional on machine made dikes.

SARRACENIACEAE, Pitcher-plant Family

Sarracenia purpurea L. pitcher-plant
Locally common in bog with the cranberry, mainland between Manns Harbor and Stumpy Point.

HAMAMELIDACEAE, Witch-hazel Family

Liquidambar styraciflua L. sweetgum, redgum
Common on the Currituck Peninsula, locally common in such wooded areas as Buxton Woods, Nags Head Woods, and Colington Island, occasional in sheltered moist depressions of the sand flats.

PLATANACEAE, Plane-tree Family

Platanus occidentalis L. sycamore
Cultivated on Roanoke Island.

ROSACEAE, Rose Family

Amelanchier oblongifolia (T. & G.) Roem. (?) shadbush
Local in moist woods, and occasional on sand flats, Bodie Island, Nags Head Woods.

Chaenomeles lagenaria Koidz flowering quince
Cultivated, Hatteras and Roanoke Islands.

Prunus serotina Ehrh. black cherry
Occasional, Currituck Peninsula, Roanoke Island and as saplings in thickets on sand flats near Bodie Island Lighthouse.

Pyrus arbutifolia (L.) L. f. red chokeberry
Frequent in pocosin on Roanoke Island.

Pyrus communis L. pear
Cultivated on Hatteras and Roanoke Islands.

Rosa palustris Marsh. (?) wild rose
Rose bushes bearing single, pink flowers were seen around the sawgrass marshes between Buxton and Frisco on Hatteras and on Roanoke Islands.

Rubus trivialis Michx. dewberry
Locally common on the higher sand flats, occasional on margins of sound side dunes from Virginia to Ocracoke Island.

Rubus spp. blackberries
Locally common on sound side dunes and in woods; Hatteras, Bodie, Roanoke Islands and lower part of Currituck Banks.

LEGUMINOSAE, Pulse Family

Albizia julibrissin Durazz. mimosa, silk tree
Cultivated, Hatteras and Roanoke Islands.

Cassia fasciculata Michx. partridge pea
Locally common in vicinity of habitations, margins of woods, and occasional on sand flats.

Centrosema virginianum (L.) Benth. butterfly-pea
Locally abundant, margin of Currituck sound, Nags Head Woods and Roanoke Island.

Clitoria mariana L. butterfly-pea
Locally common in the Nags Head Woods; and occasional along roadside on Roanoke Island.

Daubentonia punicea DC. rattlebox
Cultivated on Hatteras, Bodie and Roanoke Islands, and escaping in the vicinity of habitations; occasional in shrub margin of the marsh.

Desmodium nudiflorum (L.) DC. beggars-lice
Locally abundant along road in Nags Head Woods, and around Fort Raleigh, Roanoke Island.

Galactea volubilis (L.) Britt. milk-pea
Frequent and widespread, shrub margin of marshes and in sand flats.

Lespedeza striata (Thunb.) Hook. & Arn. Japanese lespedeza
Introduced and escaped around habitations.

Melilotus alba Desr. white sweet clover
Common along roadside at junction with marsh, Currituck Peninsula.

Pueraria lobata (Willd.) Ohwi. Kudzu
Planted, Currituck Peninsula and Banks, along roadway to Colington Island. Thriving.

Robinia pseudo-acadia L. black locust
Extensively planted in 1936-40. Plants in vicinity of Buxton are dwarfed and partly killed by salt spray. Plants in vicinity of Nags Head to Duck seemed to be in better condition.

Dolicholus minimus (L.) Medic.
Rare (?), in sand at Kitty Hawk.

Strophostyles helvola (L.) Ell. (?) wild bean
Widely distributed on margins of dunes where it is often very abundant. Positive identification not possible as plants were not in flower or fruit.

Trifolium repens L. white Dutch clover
Frequent in lawns Hatteras, Bodie and Roanoke Islands.

GERANIACEAE, Geranium Family

Geranium carolinianum L. wild geranium
A weed along paths and in cultivated ground, Hatteras and Ocracoke Islands.

RUTACEAE, Rue Family

Citrus limon Burm. lemon
Cultivated by Mrs. White, Buxton for several years. Killed by cold weather of 1954-55.

Citrus paradisi Macf. grapefruit
Cultivated by Mrs. White, Buxton for several years. Injured but not killed by the cold weather of the winter of 1954-55.

Citrus sinensis Osbeck (?) orange
Cultivated by Mrs. White, Buxton for several years. Injured but not killed by cold weather of 1954-55.

*Zanthoxylum clava-herculis L. hercules club
An important member of the thicket plants, wooded areas, sound side dunes, invading sand flats from Ocracoke Island to Virginia.

MELIACEAE, Mahogany Family

Melia azedarach L. chinaberry
Cultivated and escaping, Currituck Peninsula, Roanoke, Bodie and Hatteras Islands.

POLYGALACEAE, Milkwort Family

Polygala cymosa Walt. (and/or ramosa Ell.)
Locally abundant in moist depressions in pocosin, Roanoke Island.

Polygala lutea Walt.
Locally abundant in moist depressions in pocosin, Roanoke Island.

EUPHORBIACEAE, Spurge Family

Cnidoscolus stimulosus (Michx.) Gray — bull-nettle
Locally common at Fort Raleigh, Roanoke Island and Nags Head Woods.

Croton capitatus Michx. — goatweed
Common around habitations and cultivated fields.

*Croton punctatus Jacq. — seaside croton
Locally abundant and widespread, dunes and sand flats from Virginia to Ocracoke Island. It has some value in sand binding.

Euphorbia polygonifolia L. — beach spurge
Common, forming dense, small, prostrate mats, margins of small dunes, sand flats, Virginia to Ocracoke Island.

Ricinus communis L. — castor bean
Cultivated, occasionally an escape, Hatteras and Roanoke Islands.

ANACARDIACEAE, Cashew Family

Rhus radicans L. — poison ivy
Common and wide spread in wooded areas, occasional on sound side dunes and sand flats. There is also a shrub form, about 6 feet tall, on the sand flats north of the Caffee Inlet Coast Guard Station.

Rhus copallina L. — dwarf sumac
Wide spread but not abundant in wooded areas from Hatteras Island to Corolla, N. C.

AQUIFOLIACEAE, Holly Family

*Ilex glabra (L.) Gray — gallberry
One of important shrubs that has invaded sand flats at Bodie Island; occasional to locally abundant on Roanoke and Hatteras Islands.

*Ilex opaca Ait. — American holly
Fine trees at Fort Raleigh, Roanoke Island, Nags Head Woods, Colington Island, Buxton Woods, Hatteras and occasional on small, sound side dunes.

*Ilex vomitoria Ait. yaupon
Very abundant on dunes and sand flats from Ocracoke Island to Virginia. Plants on open sand flats are usually dwarfed and trimmed by salt spray.

CELASTRACEAE, Staff-tree Family

Euonymus japonicus L. Japanese euonymus
Cultivated, thriving, evergreen foliage resistant to salt spray injury, Ocracoke Island to Corolla, N. C.

ACERACEAE, Maple Family

Acer rubrum L. red maple
Chiefly in moist sites, Currituck Peninsula, margin of sawgrass marsh at Wright Memorial Bridge Currituck Banks, Roanoke, Bodie and Hatteras Islands.

RHAMNACEAE, Buckthorn Family

Berchemia scandens L. rattan-vine, supple-jack
Chiefly in wooded thickets, Hatteras, Roanoke Islands, Nags Head Woods, and Currituck Peninsula.

VITACEAE, Vine Family

Ampelopsis arborea (L.) Koehne pepper-vine
Common in woods, thickets on sound side dunes, and occasionally on sand flats, Ocracoke Island to Virginia.

Parthenocissus quinquefolia (L.) Planch. virginia creeper
Frequent in wooded areas, Wright Memorial Bridge, Nags Head Woods, Colington Island, Roanoke and Hatteras Islands.

*Vitis labrusca L. fox grape
Common in wooded areas, and surviving 10 to 15 feet of burial in sand dunes at Nags Head Woods; Roanoke and Hatteras Islands.

*Vitis rotundifolia Michc. scuppernong, muscadine grape
Very common and widely distributed from Ocracoke Island to Virginia in woods, thickets, sound side dunes and to a limited extent in sand flats.

TILIACEAE, Linden Family

Tilia sp. basswood
Apparently cultivated near Wanchese, Roanoke Island.

MALVACEAE, Mallow Family

Hibiscus palustris L. swamp-rosemallow
Widespread in sand flats and shrub margin of marsh, locally common on Bodie and Hatteras Islands. Two color forms, one, white with a red throat and second, all pink.

Hibiscus syriacus L. shrubby althea
Cultivated; Roanoke and Hatteras Islands.

Kosteletzkya virginica (L.) Presl. seashore mallow
Common in the shrub margins of the marshes from Ocracoke Island to Virginia.

THEACEAE, Tea or Camellia Family

Camellia sasanqua Thunb. sasanqua
Cultivated and thriving on Roanoke Island and Hatteras Island.

*Gordonia lasisanthus Ellis loblolly bay
Very abundant on the peat soils of the mainland from Stumpy Point to Manns Harbor.

GUTTIFERAE, St. John's-wort Family

Ascyrum hypericoides L. Saint Andrews cross
Widely distributed, not common, but locally abundant at times, margins of woods and on sand flats.

Hypericum gentianoides (L.) B.S.P. pineweed
Common and widespread on sand flats from Ocracoke Island to Virginia.

CISTACEAE, Rockrose Family

Hudsonia tomentosa Nutt. beach-heather
Locally common on sand flats west of Nags Head and south of Wright Memorial Bridge.

*Lechea villosa Ell. (?) pinweed
Common and widely distributed in the sand flats from Ocracoke Island to Virginia.

PASSIFLORACEAE, Passion-flower Family

Passiflora lutea L. yellow passion-flower
Local in Nags Head Woods.

CACTACEAE, Cactus Family

Opuntia drummondii Graham fragile prickly-pear
Locally abundant in sand flats on Bodie Island and occasional on Hatteras Island and Currituck Banks. This plant seems to fit the description and is within the range and habitat as given by Small. It also appears to fit the description of Opuntia fragilis (Nutt.) Haw., as given by Fernald. This area is outside of the range given and if it is the latter species, it represents an introduction. (Fig. 49a).

Opuntia humifusa Raf. (?) prickly-pear
This cactus was seen only on the sound side dunes, formerly the homesite of the Gray Family below Little Kinnakeet Coast Guard Station, Hatteras Island. It was not in flower or fruit in April. (Fig. 49b).

LYTHRACEAE, Loosestrife Family

Decodon verticillatus (L.) Ell. water-willow
Moist depressions in Nags Head Woods, and in vicinity of Buxton, Hatteras Island.

Lagerstroemia indica L. crape-mystle
Cultivated; Ocracoke, Hatteras, Roanoke, Bodie Islands and Currituck Banks and Peninsula.

PUNICACEAE, Pomegranate Family

Punica granatum L. pomegranate
Cultivated on Hatteras Island.

NYSSACEAE, Sour Gum Family

Nyssa sylvatica Marsh. blackgum
Common in wooded areas, Currituck Peninsula, ridges at Wright Memorial Bridge, Kitty Hawk, Colington Island and Roanoke Island.

Nyssa sylvatica var. biflora (Walt.) Sarg. swamp tupelo
Frequent in low ground along sound, Currituck Peninsula, occasional on margins of fresh water ponds at Nags Head Woods, Roanoke Island, and very abundant on the mainland in the peat soils from Stumpy Point to Manns Harbor.

ONAGRACEAE, Evening-primrose Family

Oenother humifusa Nutt. seabeach evening-primrose
Frequent in the sand flats and margins of dunes. Very hairy individuals were found which could readily be assigned to this species. However, there were many intermediates and plants which were more nearly typical of the taxon Oenothera lacinata Hill., cut-leaf evening-primrose.

Oenothera sp. sundrops
Frequent on sand flats near Salvo, Hatteras Island.

ARALIACEAE, Ginseng Family

Aralia spinosa L. Hercule's club

Local at Fort Raleigh, Roanoke Island.

UMBELLIFERAE, Parsley Family

Centella erecta (L.f.) Fernald
Common in moist depressions and scattered in sand flats from Virginia to Ocracoke Island.

Cicuta maculata L. water hemlock
Common in the sound side marshes from Virginia to Ocracoke Island.

Daucus carota L. Queen Anne's-lace
Locally abundant along road between Manns Harbor and Stumpy Point.

Eryngium maritimum L. beach-holly, sea-holly
A plant introduced from Europe and known only in the vicinity of habitations near the beach north of Whalebone Junction, Bodie Island (Fig. 50).

Hydrocotyle bonariensis Lam. seaside pennywort
Abundant in loose sand at margins of dunes and sand flats: Ocracoke, Hatteras, and Bodie Islands.

Hydrocotyle umbellata L. pennywort
Local and occasional around fresh water ponds, in lawn at Museum, Cape Hatteras Lighthouse.

Ptilimnium capillaceum (Michx.) Raf. mock bishop's weed
Scattered, sand flats, Hatteras, Bodie and Roanoke Islands.

Sanicula canadensis L. black snakeroot
Frequent in Nags Head Woods.

CORNACEAE, Dogwood Family

*Cornus florida L. flowering dogwood
Common in Fort Raleigh area, Roanoke Island, Nags Head Woods, and Buxton Woods, Hatteras Island.

Cornus sp. dogwood
Small plants with reddish stems in the depressions in vicinity of Cape Hatteras Lighthouse, Hatteras Island.

CLETHRACEAE, White Alder Family

*Clethera alnifolia L. sweet pepperbush
Very abundant on the peaty soils between Manns Harbor and Stumpy Point on the mainland.

ERICACEAE, Heath Family

*Eubotrys racemosa (L.) Nutt. fetterbush
Peaty soils, from Stumpy Point to Manns Harbor on the mainland and in pocosin on Roanoke Island.

*Lyonia lucida (Lam.) Koch — fetterbush
Common in peat soils on mainland between Stumpy Point and Manns Harbor and in pocosin on Roanoke Island.

Oxydendrum arboreum (L.) DC. — sourwood
Occasional, Currituck Peninsula near Coinjock.

*Vaccinium macrocarpon Ait. — cranberry
Common in peat bogs on mainland between Stumpy Point and Manns Harbor. Not present on Outer Banks.

Vaccinium stamineum L. (?) — squaw-huckleberry
Local on Roanoke Island.

Vaccinium sp. — huckleberry
Locally distributed, in wooded areas, Roanoke and Hatteras Islands.

Polycodium sp.
Occasional, small shrub in the Fort Raleigh section of Roanoke Island.

PRIMULACEAE, Primrose Family

Samolus parviflorus Raf. — water-pimpernel
Occasional, but widespread in moist habitats, margins of ditches, in marshes and woods.

Lysimachia radicans Hook.
Occasional around ponds and wet depressions in the wooded dunes, Buxton, Nags Head Woods.

PLUMBAGINACEAE, Leadwort Family

Limonium carolinianum (Walt.) Britton — sea lavender
Widespread in both sand flats and saline marshes, Ocracoke Island to Virginia.

SAPOTACEAE, Sapodilla Family

Bumelia lycioides (L.) Gaertn f. — chittumwood
Occasional on sand flats in vicinity of Caffee Inlet, Currituck Banks, and on Hatteras Island.

EBENACEAE, Ebony Family

Diospyros virginiana L. — persimmon
Moderate-sized trees at Fort Raleigh, Roanoke Island, Buxton Woods, Nags Head Woods; scattered saplings on sand flats and margins of sound side dunes from Corolla, N. C. to Hatteras.

OLEACEAE, Olive Family

Chionanthus virginicus L. Old-Man's-beard
In woods, Fort Raleigh, Roanoke Island.

Osmanthus americanus (L.) Gray wild olive
Occasional in woods, Buxton, Hatteras Island.

LOGANIACEAE, Logania Family

Gelsemium sempervirens (L.) Ait. f. yellow jessamine
Abundant in wooded areas, thickets on dunes from Virginia to Ocracoke Island.

Polypremum procumbens L.
Frequent in sand flats and in wooded thickets.

GENTIANACEAE, Gentian Family

Sabatia brachiata Ell. (?)
Widely scattered in sand flats to dry part of marshes, and in pocosin, Roanoke Island.

Sabatia dodecandra (L.) B.S.P. (?) large sea-pink
Occasional in sand flats to dry portion of marshes, widespread.

Sabatia stellaris Pursh sea-pink
Occasional but widespread on sand flats.

Sabatia paniculata (Michx.) Pursh white sabatia
Frequent in pocosin on Roanoke Island and occasional in sand flats.

APOCYNACEAE, Dogbane Family

Apocynum cannabinum L. Indian hemp
Occasional, wooded dunes, sound side dunes and invading sand flats, Hatteras and Bodie Islands.

Nerium oleander L. oleander
Cultivated; Ocracoke Island to Virginia.

Seutera maritima Decne
Occasional in dry part of salt marshes. A southern plant reaching its northern limit of distribution in North Carolina. Hatteras, Bodie and Roanoke Islands.

ASCLEPIADACEAE, Milkweed Family

Asclepias lanceolata Walt. marsh milkweed
Frequent in dryer portions of brackish and saline marshes, Currituck Peninsula, Roanoke, Bodie, Pea and Hatteras Islands.

Asclepias tuberosa L. butterfly weed
Along trails in Nags Head Woods.

Asclepias variegata L. (?) milkweed
Occasional in woods at Fort Raleigh, Roanoke Island.

CONVOLVULACEAE, Convolvulus Family

Breweria humistrata (Walt.) Gray trailing morning-glory
Common in vicinity of Fort Raleigh, Roanoke Island.

Ipomea sagittata Cav. arrow-leaf morning-glory
Occasional, in marshes, Hatteras, Bodie and Roanoke Islands.

POLEMONIACEAE, Phlox Family

Phlox sp. phlox
Apparently an excape from cultivation on Hatteras and Bodie Islands.

BORAGINACEAE, Borage Family

Heliotropium curassavicum L. sea-side heliotrope
Occasional in moist sand flats, debris zone of sound side beaches, Hatteras and Ocracoke Islands.

VERBENACEAE, Vervain Family

Callicarpa americana L. French mulberry
Common in woods and thickets, Hatteras, Bodie, Roanoke Islands, Nags Head Woods, Currituck Peninsula, and planted on dunes near Cape Hatteras Lighthouse.

Lippia lanceolata Michx. (and/or L. nodiflora (L.) Michx.) frogbit
Occasional on margins of dune, frequent in sand flats and saline marshes. This plant responds to minor environmental differences so that the usual characteristics used to separate these species cannot be applied easily in the field.

LABIATAE, Mint Family

Monarda punctata L. horsemint
Common along roadside and margins of woods, Wright Memorial Bridge, Colington Island, and ferry landing, Roanoke Island.

Teucrium canadense L. wood-sage
Occasional in margin of marsh and in moist woods, Hatteras and Bodie Islands.

Salvia splendens Sello scarlet sage
Cultivated on Roanoke and Hatteras Islands.

SOLANACEAE, Nightshade Family

Petunia violacea Lindl. (?) — petunia
Cultivated in village of Hatteras, Hatteras Island.

*Physalis maritima Curtis — maritime groundcherry
Frequent along shore dunes and in sand flats from Virginia to Ocracoke Island.

Solanum carolinense L. — horse-nettle
Occasional in sand flat near Rodanthe, Hatteras Island.

SCROPHULARIACEAE, Figwort Family

Bacopa monnieri (L.) Pennell — water-hyssop
Wet depressions, sand flats and marshes, Hatteras Island.

Gerardia maritima Raf. — seaside foxglove
Common and widespread on sand flats and into drier portions of marsh.

Gerardia virginica (L.) BSP. (?)
Occasional in Nags Head Woods. Plants lacked flowers or fruit.

Linaria canadensis (L.) Dumont — blue toadflax
Frequent in cultivated soils and along paths in Buxton.

Verbascum thapsus L. — mullen
An introduced weed; occasional in vicinity of habitations, Hatteras, Bodie and Roanoke Islands.

BIGNONIACEAE, Bignonia Family

Bignonia capreolata L. — cross-vine
Frequent on deep sand or dunes with shrub thickets, Hatteras, Roanoke Islands and Nags Head Woods.

Campsis radicans (L.) Seem. — trumpet creeper
Abundant in woods, wooded dunes, Currituck Peninsula, Nags Head Woods, Roanoke, and Hatteras Islands.

PLANTAGINACEAE, Plantain Family

Plantago aristata Michx. — bracted plantain
Sand flats near Rodanthe, Hatteras Island.

Plantago virginica L. — hoary plantain
Along grassy paths, Buxton, Hatteras Island.

RUBIACEAE, Madder Family

Cephalanthus occidentalis L. buttonbush
Common around margins of fresh water ponds on Hatteras and Bodie Islands, wet depressions on Roanoke Island and Nags Head Woods.

Diodia teres Walt. poorjoe
A common weed widely distributed on the sand flats from Virginia to Ocracoke Island.

Diodia virginiana L. buttonweed
A weed, widely distributed around habitations, old fields and occasional on sand flats.

Hedyotis uniflora (L.) Lam.
Occasional in sand flats, Hatteras and Bodie Islands.

Galium sp. bedstraw
Local in Nags Head Woods.

Galium trifidum L. (?) smooth bedstraw
Occasional on sound side dunes south of Waves, Hatteras Island.

Mitchella repens L. partridge-berry
Very abundant in the woods around Fort Raleigh on Roanoke Island, occasional in Nags Head Woods, and Buxton Woods, Hatteras Island.

CAPRIFOLIACEAE, Honeysuckle Family

Lonicera japonica Thunb. Japanese honeysuckle
Common and widespread in woods and thickets from Virginia to Ocracoke Island. Generally absent from Atlantic side dunes and sand flats.

Lonicera sempervirens L. coral honeysuckle
Common in wooded thickets on dunes Buxton, Hatteras Island, Fort Raleigh, Roanoke Island and Nags Head Woods.

COMPOSITAE, Composite Family

Achillea millefolium L. yarrow
An introduced weed; local around habitations and occasional on sand flats, Hatteras Island.

Ambrosia artemisiifolia L. lesser ragweed
A weed species around habitations and locally spreading on sand flats, Hatteras Island.

Anaphalis margaritacea (L.) Clarke pearly everlasting
Occasional clumps, sand flats, margin of marshes, and wooded areas, Hatteras, Bodie, Roanoke Islands.

Aster subulatus Michx. (?) seaside aster
Occasional in saline marshes from Virginia to Ocracoke Island.

*Baccharis halimifolia L. silverling, sea-myrtle
Very abundant and widespread, a major component of the shrub margin of the marshes, and invading the low more moist sand flats.

Bidens spp. sticktights
Locally common around fresh water ponds and depressions, Hatteras, Bodie, and Roanoke Islands.

*Borrichia frutescens (L.) DC. sea - ox-eye
An important member of the salt marsh community, common and widely distributed, occasional on sand flats.

Chrysopsis graminifolia (Michx.) Ell. golden aster
Common in sand flats, along woodland paths and occasional on lower part of dunes.

Cirsium discolor (Muhl.) Spreng. wolley thistle
Occasional, wooded areas and sand flats, Roanoke, Bodie and Hatteras Islands.

Cirsium horridulum Michx. spiny thistle
Widespread, roadsides, vicinity of habitations, occasional in sand flats.

Elephantopus nudatus Gray elephant's-foot
Locally common in Nags Head Woods.

Erechtites hieracifolia (L.) Raf. fireweed
Occasional on moist sites and margins of sand flats, Hatteras, Bodie and Roanoke Islands.

Erigeron canadense L. horseweed
Common and widely distributed; habitations, old fields, roadsides and occasional on sand flats.

Eupatorium album L.
Occasional in pocosin, Roanoke Island.

Eupatorium capillifolium (Lam.) Small yankee-weed, dog-fennel
Common and widespread, sand flats, margins of dunes, roadsides.

Eupatorium rotundifolium L. (?)
Occasional in pine pocosin, Roanoke Island.

Gaillardia puchella var. picta (Small) Gray blanket flower
Apparently an escape from cultivation; very abundant around old coast guard stations, sand flats from Virginia to Ocracoke Island.

Graphalium purpureum L. cudweed, Indian tobacco
A week, chiefly in the vicinity of habitations, Hatteras, Bodie and Roanoke Islands.

Heterotheca subaxillaris (Lam.) Britt. & Rusby camphorweed
Locally abundant on dunes in Nags Head area, and occasional on dunes and sand flats elsewhere.

Hieracium sp. hawkweed
Along trails in Nags Head Woods.

*Iva frutescens L. marsh-elder
An important and abundant shrub of the higher portion of the saline marshes; invading the moist sand flats.

Iva imbricata Walt. seashore-elder
Forms dense clumps on dunes and occasional in sand flats from Ocracoke to Virginia.

Lactuca canadensis L. (?) wild lettuce
Occasional in sand flats and around habitations.

Mikania scandens (L.) Willd. climbing hempweed
Widely distributed in the shrub margin of the saline marshes, occasional in wooded thicket and on the sand flats.

Pluchea camphorata (L.) DC. marsh fleabane
Widespread on margin of marsh and occasional in sand flats, Hatteras, Bodie and Roanoke Islands.

Pyrrhopappus carolinianus (Walt.) DC. false dandelion
Scattered, vicinity of habitations, Hatteras, Bodie and Roanoke Islands.

Solidago graminifolia (L.) Salisb. flattop goldenrod
Occasional on sand flats, Hatteras and Bodie Islands.

Solidago sempervirens var. mexicana (L.) Fern. seaside goldenrod
Common and widely distributed in sand flats from Ocracoke Island to Virginia.

Zinnia elegans Jacq. zinnia
Cultivated in villages of Hatteras, Buxton, Avon, Hatteras Island and Manteo, Roanoke Island.

LITERATURE CITED

Anonymus
1953 Fifty years of flight. 31 historic photographs. Nat. Geog. Mag. CIV: 740-756.

Ansell, Henry B.
1903-12 Recollections. Vol. 1: 62-63, two manuscript volumes 1903-1912; Southern Historical Collection, University of North Carolina.

Blomquist, H. L.
1948 The grasses of North Carolina. Duke University Press. Durham, N. C.

Boyce, Stephen G.
1954 The salt spray community. Ecological Monographs 24: 29-67.

Cobb, Collier
1906 Where the wind does the work (Cape Hatteras). Nat. Geog. Mag. XVII: 310-317.

Coker, W. C.
1905 Observations on the flora of the Isle of Palms, Charleston, S. C. Torreya 6: 135-145.

Coker, W. C. and H. R. Totten
1937 Trees of the southeastern states. 2 ed. University of North Carolina Press, Chapel Hill.

Dunbar, Gary S.
1956 Geographical History of the Carolina Banks. Coastal Studies Institute Technical Report No. 8, part A. XI +1-129.

Egler, F. E.
1942 Check list of the ferns and flowering plants of the Seaside State Park, Cape Henry, Va. New York State College of Forestry. 60 pages, mimeographed.

Engels, W.
1942 Vertebrate fauna of North Carolina coastal islands. I Ocracoke Island. Am. Mid. Nat. 28: 278-304.

Engels, W.
1952 Vertebrate fauna of North Carolina coastal islands. II Shackleford Bank. Am. Mid. Nat. 47: 702-742.

Fernald, M. L.
1950 Gray's Manual of Botany, 8th. ed. American Book Co. New York.

Goor, A. Y.
1955 Tree planting practices for arid areas. Marcel LeLoup, Director. F.A.O. Forestry Development Paper No. 6.

Guild, Capt. E. R. and J. E. Fletcher
1947 Exploring America's great sand barrier reef. Nat. Geog. Mag. XCII: 325-350.

Hitchcock, A. S. and Agnus Chase
1950 Manual of grasses of the United States. 2 ed. Misc. Pub. No. 200, G.P.O. Washington, D.C.

Johnson, D. S.
1900 Notes on the flora of the banks and sounds at Beaufort, N. C. Bot. Gaz. 30: 405-410.

Kearney, T. H.
1900 The plant covering of Ocracoke Island: a study in the ecology of North Carolina strand vegetation. U.S. Nat. Herb. Contri. 5: 261-319.

Kearney, T. H.
1904 Are plants of sea beaches and dunes true halophytes? Bot. Gaz. 37: 424-436.

La Gorce, John Oliver
1915 Warfare on our eastern coast. Nat. Geog. Mag. XXVII: 195-230.

Moss, A. E.
1940 Effect on trees of wind-driven salt water. Jour. Forestry 38: 421-425.

Lewis, I. F.
1917 The vegetation of Shackleford Bank, Carteret Co., N. C. N. C. Geol. Survey. Economic Paper 46.

Little, E. L.
1953 Check list of native and naturalized trees of the United States (including Alaska). Agriculture Handbook No. 41. G.P.O. Washington, D. C.

Nettleton, Blanche
1933 Bit of Elizabethan England in America. Nat. Geog. Mag. XLV: 695-670.

Oosting, Henry J. and W. D. Billings
1942 Factors effecting vegetation zonation on coastal dunes. Ecology 23: 131-142.

Oosting, Henry J.
1945 Tolerance to salt spray of plants of coastal dunes. Ecology 26: 85-99.

Oosting, Henry J.
1948 The study of plant communities. W. H. Freeman & Co., San Francisco, Calif. Figures 58, 59, 130.

Oosting, Henry J.
1954 Ecological processes and vegetation of the maritime strand in the southeastern United States. Bot. Rev. 20: 226-262.

Pinchot, G. and W. W. Ashe
1897 Timber trees and forests of North Carolina. N. C. Geol. Survey Bul. No. 6: 1-227.

Porter, Charles W.
1938 Maps of the forest cover in the National Seashore area. U. S. Park Service report. Unpublished.

Price, Jonathan
1795 A description of Occacock Inlet ... Newburn: Francois-x Martin Reprinted in N.C. Hist. Rev. Vol. 3: 624-633. 1926.

Rondthaler, Katherine
1952 Flowering plants of Ocracoke Island. Bachelor's thesis, Reed College, Portland, Oregon. Unpublished.

Shaler, N. S.
1895 Beaches and tide marshes of the Atlantic Coast. Nat. Geol. Monog. 1 (5): 137-168.

Shaler, N. S.
1872 The causes which have led to the production of Cape Hatteras. Proc. Bost. Soc. Nat. Hist. 14: 110-121

Small, J. K.
1933 Manual of southeastern flora. New York.

Stratton, A. C. and James R. Hollowell
1940 Sand Fixation and Beach Erosion Control. U.S.D.I. National Park Service report. Unpublished.

Stratton, A. C.
1943 Reclaiming North Carolina Banks. Shore and Beach 11, No. 11: 25-27, 32.

Welch, W. L.
1886 Opening Hatteras Inlet. Bul. Essex. Institute 17: 37-42.

Wells, B. W.
1928 Plant communities of the coastal plain of North Carolina and their successional relations. Ecology 9: 230-242.

Wells, B. W. and I. V. Shunk
1938 Salt spray: an important factor in coastal ecology. Bul. Torr. Bot. Club 65: 485-492.

Wells, B. W.
1939 A new forest climax: the salt spray climax of Smith Island, N. C. Bul. Torr. Bot. Club 66: 629-634.

Wells, B. W.
1942 Ecological problems of the southeastern United States coastal plain. Bot. Rev. 8: 533-561.

Wells, B. W.
1944 Origin and development of the lower Cape Fear Peninsula. El. Mitch. Sci. Soc. 60: 129-134.

Wells, G. S.
1954 The forests that blew away. American Forests 60: (3), 14-16, 51-52.

Figure 1.

These stumps were uncovered by hurricane "Connie" and covered again by "Diane" in September, 1955. All wood samples examined had a microscopical structure characteristic of southern hard pines. Local legends from the Civil War period report a dense live oak forest across Hatteras Island in the vicinity of Rodanthe. These stumps were about a mile or so north of Rodanthe. Photo by James P. Morgan.

Figure 2.

Wash Woods, near the Virginia-North Carolina State line. These stumps are nearly all redcedar. Historical records indicate that a forest was here in 1812; was buried and then re-exposed by 1846. This shows the rapidity of change that occurs on the Outer Banks. It is also evidence for the belief that there was more extensive distribution of forests in the past than today.

Fig. 1

Fig. 2

Figure 3.

A live oak stump in situ from a different segment of the Wash Woods forest than in the above illustration. This indicates that a maritime forest of live oak - redcedar grew on a site where it cannot exist today.

Figure 4.

Skeletons of large live oaks on the sound side dunes south of the Little Kinnakeet Coast Guard Station, Hatteras Island. Some of these dead trees measured 24 to 30 inches in diameter.

Fig. 3

Fig. 4

Figure 5.

This is an example of Type A, brush-panel fencing as described by Stratton and Hollowell. It shows the batten board, the brush filler, posts, and bracing spur panel. Some 557 miles of sand fencing were erected in 1936-40. The brush impedes the flow of the wind just enough to reduce its capacity to carry the sand, and thus the sand accumulates. Bodie Island.

Figure 6.

This brush panel fence trapped this quantity of sand in less than 3 months. Bodie Island.

Fig. 5

Fig. 6

Figure 7.

This black locust is probably the remains of a planting made in 1936-40. These trees grow slowly here. They are full of dead branches. The foliage was killed by the salt spray from the 1954 hurricanes.

Figure 8.

This pine plantation south of Salvo, is nearly a mile long and about 1/4 mile wide. It was planted in 1936-40. Notice how the contour of the crowns slopes downward from the left to the right. These trees are all of the same age. It shows the gradual fall-out of salt spray. The trees on the right are nearest to the Atlantic Ocean, which is a good half mile away. Six major storms in two years have severely injured the needles, reduced the food supply, and actually killed the new growth on the younger branches.

Fig. 7

Fig. 8

Figure 9.

Live sand is in the process of burying the bayberry-live oak thicket. This vegetation has trapped some sand and will hold more. Near the ferry landing on Bodie Island.

Figure 10.

These shrubs have trapped a considerable quantity of drifting sand and are being buried. The leafless condition probably is the result of salt spray injury from hurricanes "Carol" and "Edna" in 1954. This photograph illustrates how effective thick shrubs can be in trapping sand and building a dune. Near ferry landing on Bodie Island.

Fig. 9

Fig. 10

Figure 11.

After the shrubs die and the wood deteriorates, there is nothing to prevent the sand from blowing away again if the dune lacks a grass cover. This blowout is about 200 feet from figure 10. Near ferry landing on Bodie Island.

Figure 12.

There are many small hammock or haycock dunes near the Park Service Headquarters, Bodie Island. It is evident that the grass cover of the dunes was not uniform, or was opened by man, and the sand was etched away by the winds. The grasses here are sea oats and running beach grass.

Fig. 11

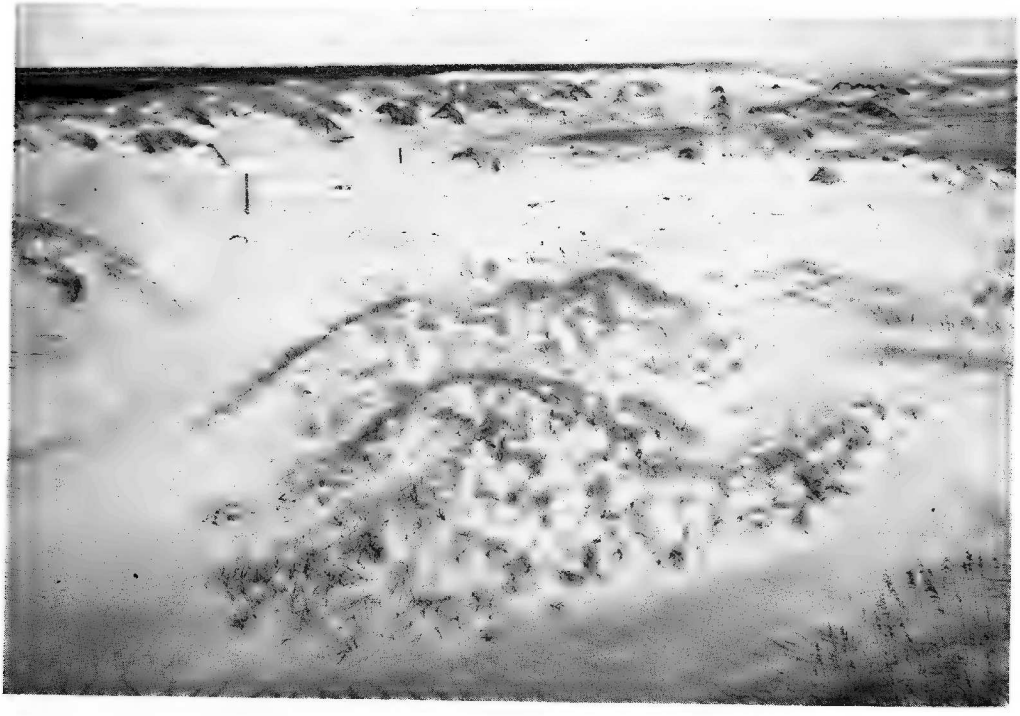


Fig. 12

Figure 13.

A dune covered with the American beachgrass. This illustrates the density of growth this plant can make, which is one of the reasons why it is so successful in sand stilling.

Figure 14.

A dune capped with sea oats, Bodie Island.

Fig. 13

Fig. 14

Figure 15.

The creeping beachgrass, Panicum amarum, produces quantities of rhizomes which have a single culm at each node. The aggregate of rhizomes and fine roots anchor considerable quantities of sand and, when too deeply buried, new layers of roots are produced from the upper culm nodes.

Fig. 15

Figure 16.

The waves stirred up by hurricane "Hazel" in October, 1954, cut this dune and exposed the culms of the American beachgrass. The original grass level is indicated by the arrow to the right of the figure's heel. The other arrows mark three additional layers of roots. These indicate that the plant has survived four successive burials, thus marking not only its progress in growing upward but also in the development of the sand dune. Note the progressive division and expansion of the plant as it grows upward. Southwest end of Hatteras Island.

Fig. 16

Figure 17.

Prostrate live oak. This type of growth occurs on the miniature dunes adjacent to the beach south of the Cape Hatteras Lighthouse. There are a few small, dead branches visible. This prostrate form is caused by the salt spray toxicity.

Figure 18.

Live oak on top of low dunes near Cape Hatteras Lighthouse. The branches grow away from the windward side. Note the small, leafless, dead branches in the top of the brown in the center of the photograph. The even, sheared appearance of the crown to the left of these dead branches is typical of trees in this area.

Fig. 17

Fig. 18

Figure 19.

View of the saw-grass marsh between wooded ridges. The tree skeletons on the islands are live oak and the tall trees in the background are pines. Photo taken between Buxton and Frisco, Hatteras Island.

Figure 20.

(A.) This live oak has a clear bole of about 20 feet. It grew near the base of the dunes in Buxton Woods.

(B.) This live oak grew near the crest of the dunes. It has a short trunk, contorted branches, a multitude of small, pin branches on the large horizontal branch. This tree is more exposed to salt spray than (A).

Fig. 19

Fig. 20

Figure 21.

Detail of the grass planted in 1936-40 on a sand dune near Kitty Hawk. The dune is "now moving inland and encroaching on evergreen maritime forest." Figure 58 of "The Study of Plant Communities" by Henry J. Oosting. Photograph by C. F. Korstian, courtesy of Dr. Oosting.

Figure 22.

Live sand from the Seven Sisters Dunes at Nags Head has spread across the island and buried the forest on its way to the sound.

Fig. 21

Fig. 22

Figure 23.

View of sand flat near Rodanthe, Hatteras Island. The dwarfed, sparse vegetation is quite characteristic of large stretches of these sand flats. It is composed of a mixture of grasses and herbs.

Figure 24.

A sand flat between Hatteras village and the southwest tip of Hatteras Island, along the inside road. This shows the density of the saltmeadow cordgrass, sandrush, and the broad-leaved plants, of which the Mexican goldenrod is the chief plant.

Fig. 23

Fig. 24

Figure 25.

Sand flats north of Corolla, N. C. Much of this area now has a good grass cover of saltmeadow cordgrass. The tree area in the background was not visited.

Figure 26.

Aerial view of a portion of Bodie Island northwest of the Park Service Headquarters. This photograph shows an intermittent pond (A), small knolls with live oak and wax-myrtle (B), sound side dune with fence line (C), and drainage canals (D). Note the quantity of vegetation that has invaded the spoil bank of the canal since it was constructed. Photo reduced to 1:12,900 (approx.).

Fig. 25

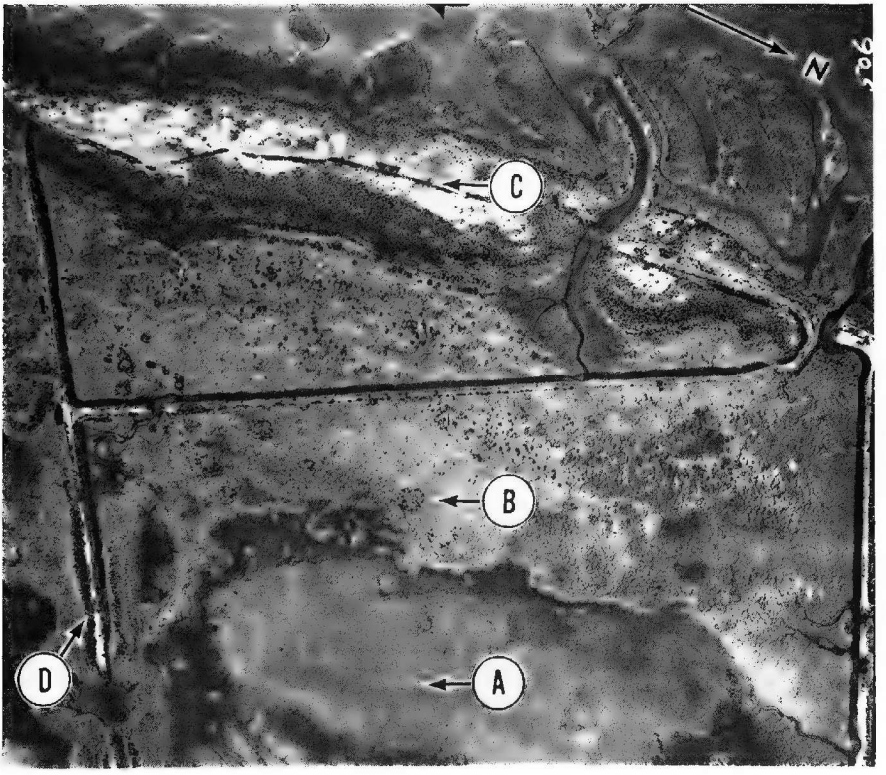


Fig. 26

Figure 27.

This snow fence was erected by the North Carolina Highway Commission in 1952 in front of a low area north of Corolla on the Currituck Banks. Here the secondary line of fence is too far back from the primary fence, and there is a hollow back of the first dune as is shown in the center of the photograph.

Figure 28.

The secondary fence was constructed in a zigzag arrangement. At this location, the two fences are close enough together to have trapped a solid wall of sand more than 100 feet wide. Photo north of Corolla, N. C., on Currituck Banks.

Fig. 27

Fig. 28

Figure 29.

Aerial view of Whalehead property and Coast Guard Station at Corolla, N. C., made about 1938. This shows a single barrier dune, formed over brush fencing. (A). The bracing panels are still visible. The grass planting shows up back of this dune as a series of tiny dots in definite rows. (B). Note the open, bare sand back of the grass planting. A portion of this now has a small plantation of small pines, see figure 33. The dark area on the upper third of the picture consists of sound side dunes with low vegetation, marshland beyond. Photograph courtesy Mr. Ray T. Adams, Washington, D. C.

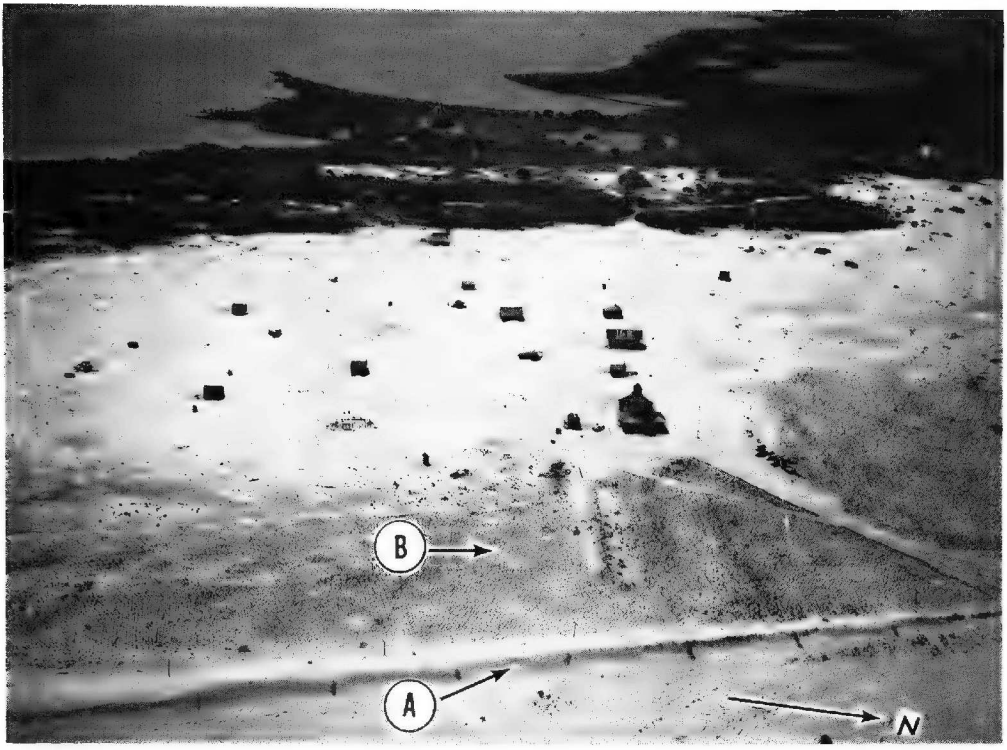


Fig. 29

Figure 30.

Aerial view in vicinity of Cape Hatteras Lighthouse made between 1936-1940. Compare with Plate IV and figures 31 and 32 for changes in physiography and vegetation. Items of interest are located by the following letters: A, Sand fences and resulting dunes. B, Civilian Conservation Corp camp. C, Lighthouse. D, Area of nearly bare sand. E, sawgrass marsh between two sand ridges. F, pond in sawgrass marsh. G, trails at the base of ridges. H, dark streak interpretated as a pond at the base of the lighthouse. I, location of pond on 1872 map.

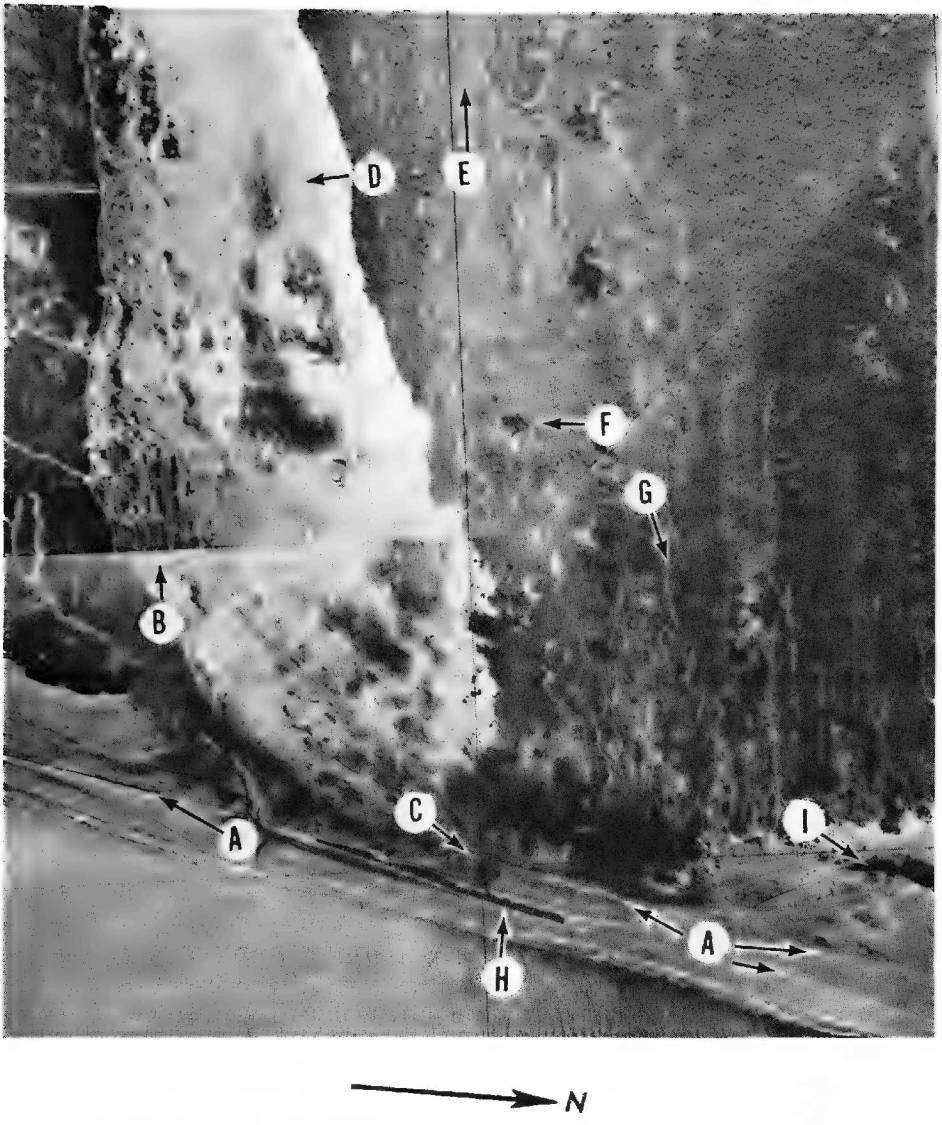


Fig. 30

Figure 31.

Aerial view of vicinity of Cape Hatteras Light made about 1946 (?). The letters indicate the same objects as in figure 30. The following are some of the obvious changes: vegetation caps the tops of the dunes A. The foundation of the Civilian Conservation Corp camp is located by B. Note the greater quantity of vegetation in the area designated as D. There are more ponds in the saw-grass marsh between the ridges. The pond marked by F is larger. The pond at H has disappeared.

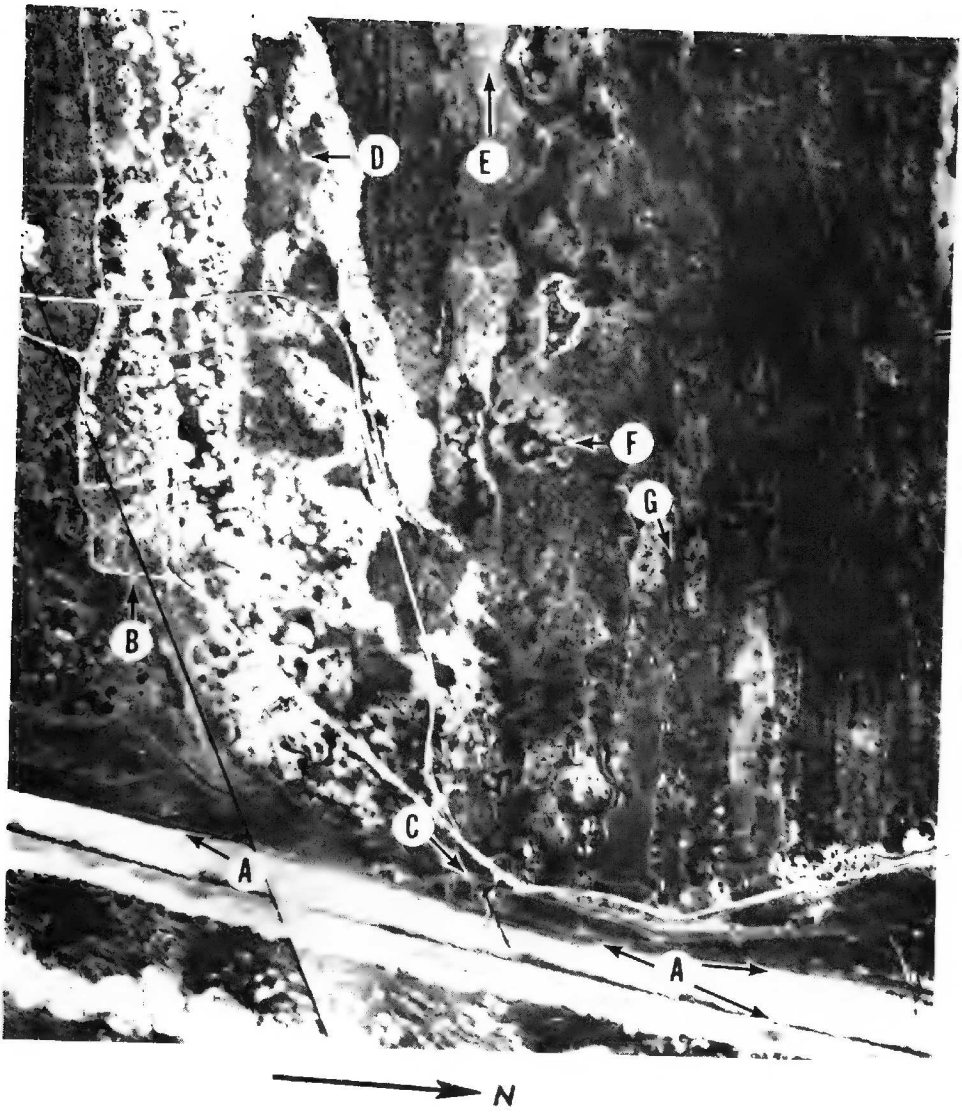


Fig. 31

Figure 32.

Aerial view of vicinity of Cape Hatteras lighthouse made in 1952.

The letters designate the same objects as in figures 30 and 31. There is more grass cover on the dune A. The change of the bare area D in a space of about 14 years is very striking. The white areas indicate deeper sand and the tiny dark dots in the small white spots are shrubs on small sand mounds. The contrast between the saw-grass marsh and the ponds shows distinctly at F.

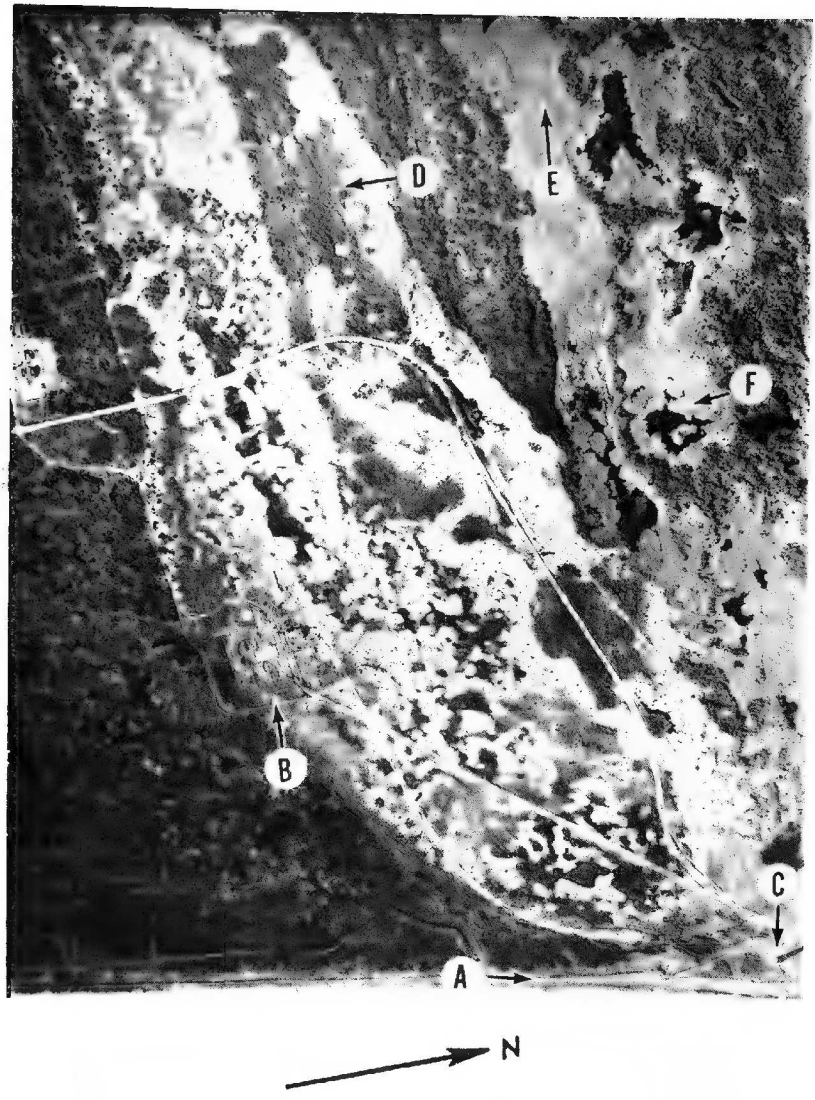


Fig. 32

Figure 33.

Photograph of a young pine plantation near Corolla, N. C. This is the area which shows up as bare sand in figure No. 29. The grass in the foreground is American beachgrass and saltmeadow cordgrass. Photo by Mr. Verde Watson, Park Naturalist.

Fig. 33

Figure 34.

The sand flats a short distance south of figure No. 33. This shows the variation in grass cover from bare sand to local grass patches plus volunteer seedlings of such hardwoods as live oak, yaupon, and wax-myrtle. Photo by Mr. Verde Watson, Park Naturalist.

Figure 35.

Barrier dune from the beach near the base of Cape Hatteras Lighthouse. This shows the stratification of the sand, and plant remains in the sand. It also shows how the waves have made nearly a vertical cut of the seaward face of this dune.

Fig. 34

Fig. 35

Figure 36.

View from top of Cape Hatteras lighthouse looking north. The arrows mark the location of fences which caused these dunes to form. Note the vegetation on the lee side of the outer dune is less abundant than on the next two dunes, although it is probable that some of the woody plants between the second and third dunes were planted. The partial lack of a planting pattern suggests that some are volunteers that developed after the sand was stabilized.

Figure 37.

A view from the top of Cape Hatteras Lighthouse looking southwest. This is an area that is classified as miniature sand dunes or a rolling dry sand flat. The darkest black spots are such plants as live oak, yaupon, or wax-myrtle. The remains of a pine plantation are in the upper third of the picture where the right hand road narrows. The maritime pine was planted in this area.

Fig. 36

Fig. 37

Figure 38.

This shows the relationship of vegetation to the slight differences in elevation in the hummock-like dunes south of Cape Hatteras Lighthouse. The depression between the sandy mounds has a variety of grasses and herbs but the mounds are sparsely covered, except for a few dwarfed shrubs such as live oak, yaupon, and wax-myrtle.

Figure 39.

This sheared-appearing shrubbery is chiefly live oak with occasional clumps of yaupon. This growth form is attributed to the toxicity of salt spray. Although this growth is on a slope, the plants are taller near the crest than at the foot of the slope. Truncated dunes near Cape Hatteras Lighthouse.

Fig. 38

Fig. 39

Figure 40.

Sheared yaupon on sand flats near pine plantation in vicinity of Salvo, Hatteras Island.

Figure 41.

Sea-shore elder, Iva imbricata. This illustrates the dense cover of one plant. It produces an abundance of seed and the foliage is moderately resistant to salt spray. The grasses in the foreground are saltmeadow cordgrass, sea oats, and perhaps American beachgrass. Photo near Rodanthe, Hatteras Island.

Fig. 40

Fig. 41

Figure 42.

Sea oats, Uniola paniculata, can be recognized by the heavy panicles of large, conspicuously flattened spikelets, borne on tall, coarse culms. This was planted in the sand stilling project of 1936-40. It is the most abundant grass on the barrier dune from Virginia to the southern end of Hatteras Island, and on the natural dunes of Ocracoke Island. Photo on dunes north of Rodanthe.

Fig. 42

Figure 43.

American beach grass, Ammophila breviligulata, grows in very dense clumps. It was one of the grasses planted in the sand stilling project. It can be recognized in the fruiting stage by the dense, cylindrical spikes. It grows well in sand and is quite tolerant to salt spray. It is very abundant from Virginia to the southern end of Hatteras Island. Photo on dunes north of Rodanthe.

Fig. 43

Figure 44.

Knotgrass, Paspalum vaginatum. This native grass has unusual possibilities for sand fixation. It should be planted on all sand road shoulders. Wherever it is present in sufficient abundance, cars can drive on the road shoulders and back on to the road without getting stuck in the sand.

Figure 45.

Saltmeadow cordgrass, Spartina patens. A very important sand binding grass which is a pioneer on the bare sand here between the dune and the water on the southwest tip of Hatteras Island.

Fig. 44

Fig. 45

Figure 46.

These Spanish dagger plants, Yucca gloriosa, were planted on a sand dune on the site of a former hunting club south of the Pea Island Coast Guard Station. These plants not only trap sand and thrive under these conditions, but also successfully keep man and animals out of an area. Note the quantity of small roots exposed on the edge of the dune.

Figure 47.

Sand ridge thrown up with machinery by the North Carolina Highway Commission. This bare sand ridge withstood the impact of three hurricanes in 1954 and three in 1955. Sound tides from hurricane "Edna" finally washed over part of this dike. North of Rodanthe, Hatteras Island.

Fig. 46

Fig. 47

Figure 48.

Purple muhly, Muhlenbergia capillaris. This grass grows in dense clumps on the dry sand flats. It is very attractive in the late summer and fall when the delicate, purple colored, inflorescence is newly opened. This is one of the native grasses which has made a comeback since grazing has been restricted. Near Avon, Hatteras Island.

Figure 49.

(A.) Fragile cactus, Opuntia drummondil. The joints of this cactus separate easily and thus the plant spreads rapidly. It is more abundant on Bodie than on Hatteras Island. Photo on Hatteras Island.

(B.) Opuntia humifusa (?) This flat pad cactus was found on the sound side dunes only in the vicinity of the Gray family cemetery, south of Little Kinnakeet Coast Guard Station.

Fig. 48

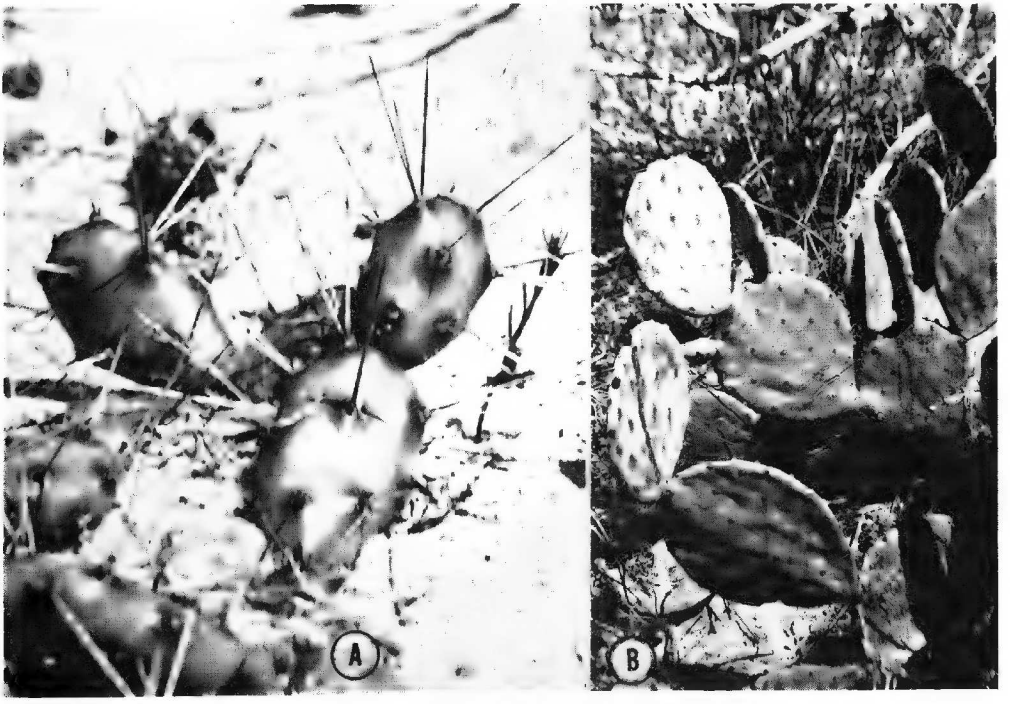


Fig. 49

Figure 50.

Beach holly, Eryngium maritimum. This is a rare plant of local occurrence on the sand near Whalebone Junction, Bodie Island. The insert shows the detail of the flower cluster. It is an introduction from Europe.

Fig. 50